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A Note on Dynamics Near the Equator, in View of the Recent Observations in the Eastern Equatorial Pacific*

By

Kozo YOSHIDA**

Abstract: It is pointed out that a model of dynamical balance discussed by Weenink and Groen (1953) appears to lead to a solution which involves a discontinuity in the vicinity of the equator. The origin of this unreasonable singularity is found to be in the assumed density model. A modification for density model near the equator which seems more realistic in view of recent observations is suggested to yield a reasonable solution.

Introduction

There have long been controversial questions concerning a dynamical balance at and very near the equator, where geostrophic acceleration is vanishingly small. More observations are certainly needed to make any approach to this problem. The present note is therefore concerned only with suggestive remarks on this problem, in view of recent observations in the equatorial regions and of recent discussions on dynamical balance. (Sverdrup, 1947; Reid, 1948 a, b; Munk, 1950; Weenink and Groen, 1952; Yoshida, Mao and Horrer, 1953; Cromwell, 1953; Jerlov, 1953; Cromwell et al, 1954; Montgomery, 1954; Wooster and Jennings, 1955; Hidaka, 1955; Tsuchiya, 1955).

In their theories, Sverdrup, Reid and Munk have suggested that the balance is nearly established between terms of geostrophic, pressure gradient and vertical mixing, at least as far as the masstransport is concerned. There should be no singularity across the equator as far as those vertically integrated model is concerned. Weenink and Groen (W-G) derived a solution for surface current at the equator, based on a balance between the above three terms. According to them, surface current velocity is

$$u_0 = \frac{1}{A}\int_0^D \frac{\partial p}{\partial x} z dz \tag{1}$$

$$v_0 = \frac{1}{A}\int_0^D \frac{\partial p}{\partial y} z dz \tag{2}$$

where A is eddy viscosity, x and y point positively eastward and northward, z points downward, u_0 and v_0 are the eastward and northward component of the surface velocity, D is a total depth of the water. Assuming Reid's density model, it follows

$$u_0 = \frac{8}{5}\frac{\tau_x h}{A} \tag{3}$$

$$v_0 = \frac{8}{5}\frac{\tau_y h}{A} \tag{4}$$

where h is a thickness of the upper mixed layer, and τ_x and τ_y are the eastward and northward components of wind stress respectively.

These simple results should provide convenient means of measuring surface current at the equator, if they are proved valid. On the other hand, Tsuchiya (1955) indicated that the following equation appears to be valid at the equator, based on recent data from Hawaiian observations (U.S. Fish and Wildlife Service, 1954):

$$u = -\frac{1}{\beta}\frac{\partial^2 p}{\partial y^2} \tag{5}$$

where u is an eastward component of the velocity, and $\beta = df/dy$.

The above two formulae (1) and (5) may both be available to numerical computations from density, and may differ entirely from each other. Future observations should be

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desired to test them. It will be found, on the other hand, that W-G's solution appears to lead to a discontinuity in meridional masstransport across the equator, though this discrepancy was not revealed in their derivations of surface current velocities. The discrepancy is also revealed by an unreasonable result that the solution yields "descending velocity at the sea surface" of considerable amount. In fact, a condition at the sea surface should require possible types of density structure at and very near the equator to be somewhat limited. Hence it may be suggested that the assumed dynamical balance may not be responsible for the singularity, but that the assumed density model may be responsible. This appears to be in agreement with actual density features revealed by numbers of recent observations which indicated a trough in isotherms or isopycnals underlying a crest at the equator, in some contrast to the Reid's model (Wooster and Jennings, 1955; Cromwell, 1953; Montgomery, 1954). The Equatorial Undercurrent, recently discovered, might be related to this (Cromwell, Montgomery and Stroup, 1954).

Discontinuity Due to Assumed Model

It can be seen that W-G's solution leads to a meridional masstransport

$$M_y=\frac{13\,h^2}{6A}\tau_y \quad \text{for} \quad f=0 \qquad (6)$$

where f is Coriolis parameter, M_y is northward component of masstransport, τ_y is the northward component of wind stress, h is a thickness of the upper mixed layer and A is eddy viscosity assumed constant. On the other hand, under the assumed model, we should have at the equator

$$M_y=\frac{\mathrm{curl}_x\tau}{\beta} \quad \text{for} \quad f=0 \qquad (7)$$

Data of wind stresses in the regions may indicate that τ_y is positive (0.1 dynes/cm^2, for average) and curl τ is negative (roughly 0.5×10^{-8} dynes/cm^3).

This may be approximately true along the equator in eastern Pacific, and therefore, there should be significant departure between (6) and (7) (see Discussion). Furthermore, it will be seen that the condition (7) does not represent that of no vertical velocity at both of the surface and bottom of the ocean for the narrow equatorial belt as Coriolis parameter approaches to zero. The condition for this should be introduced for these very low latitudes, as given by

$$\frac{\partial M_y}{\partial y}=\frac{1}{\beta}\frac{\partial\,\mathrm{curl}\tau}{\partial y} \quad \text{for} \quad f=0 \qquad (8)$$

These two conditions (7) and (8) are required only for very low latitudes where they are independent of each other, while, in other latitudes, the condition (8) is automatically fulfilled by (7). This may imply that a density model of a single parameter like Reid's cannot satisfy our requirement at the equator, but that a model of at least two parameters will be needed. This is true whether eddy viscosity (A) is assumed constant as W-G did or not.

Now, it is suspected that the system dealt with by W-G may lead to a vertical velocity at the sea surface which is not negligible by any means. According to W-G model, the vertical velocity at the surface, w_0, is found to be

$$w_0=\frac{13}{6A}h^2\,\mathrm{div}\,\tau+\frac{13}{15Ag\Delta\rho}(\tau_x^2+\tau_y^2)-\frac{2579}{1800}\frac{h^4\beta}{A^2}\tau_x \qquad (9)$$

where, $\Delta\rho$ is a difference between surface density and bottom density, τ_x is an eastward component of wind stress and $\beta=df/dy$. The numerical values from wind stress data (Reid, 1948) may approximately give

$$\tau_x\sim-0.4, \qquad \tau_y\sim+0.1,$$
$$\frac{\partial\tau_x}{\partial x}\sim+0.1\times10^{-8}, \qquad \frac{\partial\tau_y}{\partial y}\sim+0.8\times10^{-8}$$

Putting $\Delta\rho\sim2\times10^{-3}$, $\beta\sim2\times10^{-13}$ and $h\sim0.7\times10^4$, rough estimates of w_0 are given as follows:

$$w_0\sim5\times10^{-2}\ \text{cm/sec} \quad \text{for} \quad A\sim10^2$$
$$\sim2\times10^{-3}\ \text{cm/sec} \quad \text{for} \quad A\sim10^3$$

Although a magnitude of A is somewhat uncertain, the values of w_0 are positive, indicating downward, and would not be less than 10^{-3} cm/sec. This is considered quite unreasonable, and moreover, is in definite disagreement with surface vertical com-

ponent of velocity given by kinematical surface boundary condition:

$$u_0\frac{\partial z_0}{\partial x}+v_0\frac{\partial z_0}{\partial y}=-\frac{16}{25gA}(\tau_x^2+\tau_y^2) \qquad (10)$$

z_0 being surface elevation, which gives

$$w_0\sim-1\times10^{-6}\,\text{cm/sec} \quad \text{for} \quad A\sim10^2$$
$$\sim-1\times10^{-7}\,\text{cm/sec} \quad \text{for} \quad A\sim10^3$$

Hence, w_0 derived from horizontal divergence at the equator is entirely different from this value required by surface kinematical condition. A question may arise, however, whether or not such discrepancy in small surface divergence or meridional masstransport would seriously affect the surface distributions of currents derived by W-G, and we shall return to this question in later section.

Elimination of the Singularity

It was suggested in last sections that some modified density model is required very near the equator. An inspection into vertical sections may indicate that a trough in isopycnals underlies an upper crest in the vicinity of the equator (Fig. 1). Relatively homogeneous density in the layer between the crest and trough, say, 50 to 100 m, and also rather sharp increase in density beneath the trough might possibly suggest that vertical mixing may reach this layer. In the upper mixed layer, the meridional variation in surface density may be considerable, with lowest density at latitudes somewhat north of the equator, say, at 5 to 9°N, though somewhat different in different oceans. It is considered that such meridional variation in surface density contributes significant amount to meridional pressure gradient. Now, as a first attempt, it is assumed that surface density ρ_0 in Reid's model is replaced by $\rho_0(y)$ which varies from latitude to latitude near the equator. By assuming this, for simplicity, it can be seen that

$$M_y=\frac{1}{2A}\left(\frac{13}{3}\tau_y h^2+\frac{65}{12}gh^4\frac{\partial\rho_0}{\partial y}\right) \qquad (11)$$

This indicates that M_y at the equator will be in agreement with that required from curl τ, provided that $A\sim10^3$ and $\frac{\partial\rho_0}{\partial y}\sim-10^{-11}$. It may be quite possible that this is approximately fulfilled (Fig. 2). This new model yields

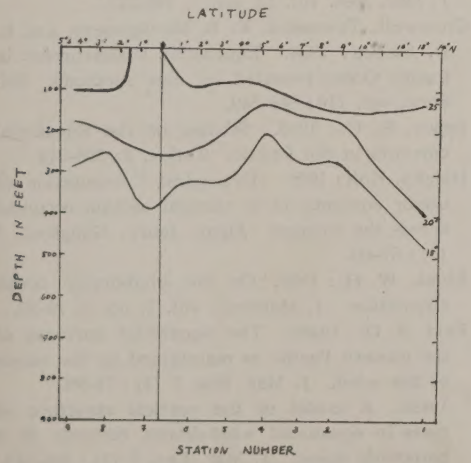

Fig. 1. Temperature-depth section from bathythermograph profile, M.V.N.B. Scofield cruise, Jan. 23 to Mar. 18, 1953. 100°W—92°W. (westernmost section of the cruise), (after Warren S. Wooster and Feenan Jennings), (after Warren S. Wooster, 1955, Fig. 6).

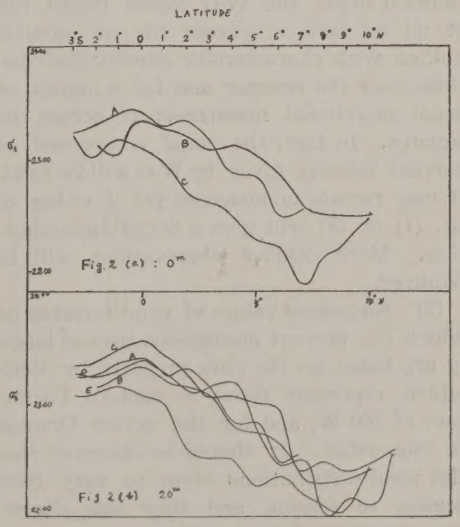

Fig. 2. Surface density (σ_t); from the Hugh M. Smith Oceanographic observations.
(a) 0m: A. 165°W, Feb. B. 172°W, Mar. C. 172°W, July.
(b) 20m: A. 165°W, Feb. B. 172°W, Mar. C. 158°W, Jan. D. 158°W, July. E. 172°W, July.

$$\frac{\partial h}{\partial y}=\frac{1}{5gh\Delta\rho}\left(\tau_y+\frac{5}{2}gh^2\frac{\partial \rho_0}{\partial y}\right) \qquad (12)$$

which indicates the meridional inclination of a depth of thermocline is nearly -3.5×10^{-5}. This suggests that isopycnals in thermocline layer rise toward north and might suggest equatorial undercurrent.

The solution for surface current velocity is valid for predominant component, u_0, as given by W-G. For meridinal component, v_0, modification is needed as

$$v_0=\frac{8\tau_y h}{5A}+\frac{4gh^2}{3A}\frac{\partial \rho_0}{\partial y} \qquad (13)$$

which may imply that v_0 is much smaller than u_0 as compared with the W-G's result and this looks more reasonable.

Consequently, the above modification in density model may only require that W-G's relation between v_0 and τ_y (4) should be altered and eq.s (1) to (3) will remain valid.

Discussion

(1) A discontinuity near the equator which appears to be encountered in the solution under the W-G model might not at all be serious, except for its possible linking with characteristic density distributions near the equator and for a matter of small meridional masstransport across the equator. In fact, the zonal component of current velocity given by W-G will be valid. It may remain unanswered yet if either of eq. (1) or (5) will give a better approximation. More detailed observations will be required.

(2) Numerical values of wind stresses on which the present discussions depend largely are based on the data prepared by Reid, which represent those in eastern Pacific, east of 160°W, and for the period October to November. It should be observed that the wind distributions seem to vary from season to season, and they also depend upon longitude largely. For an example, τ_y along the equator is negative, in general, in the western Pacific, whereas it is positive in the eastern Pacific. The oceanographic sections which are refered to were taken in various seasons and longitudes: (Cromwell, 172°W, January to February; 158°W, July to August; Montgomery, 158°W, February to March; Wooster et al, east of 95°W, January to March: Hough M. Smith cruises: 172°W, June to August. 158°W, January to March; 165°W, January to March; Mao and Yoshida, 155°E to 175°E). Therefore, it may be better to use the wind data for February, if the oceanographic sections are refered from February cruise. It will be seen that more or less similar result comes out also when the February wind data are employed, and the discussions will not essentially be altered. The presence of the discontinuity and its linking with the observed density structure are not proved, but, we would say, merely suggested.

(3) Hypothetically, there may be various possibilities of eliminating the singularity at the equator. A theory taking account of lateral mixing (Yoshida et al, 1953) would be an example, though it involves an arbitrariness in assumed magnitude of lateral mixing.

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Note on the Convective Circulation (II)*

By

Kenzo TAKANO**

Abstract: The meridional variation in the Coriolis parameter causes an intensification of the vertical upward current in the vicinity of the equator in a convective circulation induced by density differences between the equatorial and polar regions in a zonal basin comparable in size to the Pacific Ocean.

Introduction

It has been already found that, with regard to a convective current due to the meridional density differences maintained at the surface in a closed rotating basin where the Coriolis parameter is assumed a constant, the intense upwelling occurs near the western boundary and the intense sinking near the eastern boundary and there is no longitudinal variation in the current velocity in the central portion (Takano, 1955). We intend to estimate the effect of the variation of the Coriolis parameter in a zonal basin, assuming that the resistance due to the eddy viscosity may be proportional to the velocity.

Effect of the variation of the Coriolis parameter

Taking the origin on the equator, the x-axis positive eastward, the y-axis northward, the z-axis vertically downward, neglecting the inertia terms and the terms including the vertical velocity and replacing the terms of the eddy viscosity by $-ku$ and $-kv$, we have the equations of motion

$$-ku+\rho fv=\frac{\partial p}{\partial x}, \tag{1}$$

$$-kv-\rho fu=\frac{\partial p}{\partial y}, \tag{2}$$

$$0=\frac{\partial p}{\partial z}-g\rho. \tag{3}$$

Here, u, v are the components of the current velocity in the x- and y- directions, ρ the density, p the pressure, k a constant, g the accerelation of gravity and f the Coriolis parameter given by $2\omega\sin\varphi$ where ω is the angular velocity of the earth and φ the latitude.

The equations (1) to (3) are transformed into

$$-k\frac{\partial u}{\partial z}+f\frac{\partial v}{\partial z}=g\frac{\partial \rho}{\partial x}, \tag{4}$$

$$-k\frac{\partial v}{\partial z}-f\frac{\partial u}{\partial z}=g\frac{\partial \rho}{\partial y}, \tag{5}$$

which are further reduced to

$$(k^2+f^2)\frac{\partial v}{\partial z}=-kg\frac{\partial \rho}{\partial y}, \tag{6}$$

provided there is no longitudinal variation in the density.

The equation of continuity of mass is written as

$$\frac{\partial}{\partial y}(\rho v)+\frac{\partial}{\partial z}(\rho w)=A_h\frac{\partial^2\rho}{\partial y^2}+A_v\frac{\partial^2\rho}{\partial z^2}, \tag{7}$$

where w is the vertical velocity, A_h and A_v the horizontal and vertical eddy diffusivities.

When the left-hand side in the above equation is negligibly small as a first approximation, it becomes

$$A_h\frac{\partial^2\rho}{\partial y^2}+A_v\frac{\partial^2\rho}{\partial z^2}=0, \tag{8}$$

of which we have the solution, denoting the meridional length of the basin by $2l$,

$$\rho=-\Delta\rho\cos\frac{\pi}{l}(y-y_0)\left(\cosh\frac{\pi}{l}\sqrt{\frac{A_h}{A_v}}z-\coth\frac{\pi}{l}\sqrt{\frac{A_h}{A_v}}H\cdot\sinh\frac{\pi}{l}\sqrt{\frac{A_h}{A_v}}z\right)+\beta_0 z, \tag{9}$$

with the boundary conditions:

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$$\rho=-\Delta\rho\cos\frac{\pi}{l}(y-y_0)$$

at the surface $(z=0)$, (10)

$$\rho=\beta_0 H$$

at the bottom $(z=H)$, (11)

y_0 being a constant which gives the latitude of the minimum surface density. According to the equation of continuity:

$$\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=0, \tag{12}$$

which is approximately derived from the equation (7), the stream function ψ is introduced so that

$$\left.\begin{aligned} v&=\frac{\partial\psi}{\partial z}\\ \text{and}\quad w&=-\frac{\partial\psi}{\partial y}\end{aligned}\right\}. \tag{13}$$

The equation (6) combined with (9), (13) and the boundary conditions

$$\psi=0 \quad \text{at} \quad y=l,\ z=0,\ H \tag{14}$$

gives

$$\psi=-\frac{kg\Delta\rho}{\pi\frac{A_h}{lA_v}(k^2+f^2)}\sin\frac{\pi}{l}(y-y_0)\left(\cosh\frac{\pi}{l}\sqrt{\frac{A_h}{A_v}}z-\coth\frac{\pi}{l}\sqrt{\frac{A_h}{A_v}}H\cdot\sinh\frac{\pi}{l}\sqrt{\frac{A_h}{A_v}}z+\frac{z}{H}-1\right), \tag{15}$$

$$v=-\frac{kg\Delta\rho}{\pi\frac{A_h}{lA_v}(k^2+f^2)}\sin\frac{\pi}{l}(y-y_0)\left\{\frac{\pi}{l}\sqrt{\frac{A_h}{A_v}}\times\left(\sinh\frac{\pi}{l}\sqrt{\frac{A_h}{A_v}}z-\coth\frac{\pi}{l}\sqrt{\frac{A_h}{A_v}}H\cdot\cosh\frac{\pi}{l}\times\sqrt{\frac{A_h}{A_v}}z\right)+\frac{1}{H}\right\}, \tag{16}$$

$$w=-\frac{kg\Delta\rho}{\pi\frac{A_h}{lA_v}(k^2+f^2)}\left(\frac{2\beta f}{k^2+f^2}\sin\frac{\pi}{l}(y-y_0)-\frac{\pi}{l}\times\cos\frac{\pi}{l}(y-y_0)\right)\left(\cosh\frac{\pi}{l}\sqrt{\frac{A_h}{A_v}}z-\coth\frac{\pi}{l}\times\sqrt{\frac{A_h}{A_v}}H\cdot\sinh\frac{\pi}{l}\sqrt{\frac{A_h}{A_v}}z+\frac{z}{H}-1\right), \tag{17}$$

where $\beta=\frac{df}{dy}$ and we assume $\frac{d}{dy}\sin\varphi=\frac{\cos\varphi}{R}$ (R: radius of the earth).

Since the vertical velocity vanishes provided $\tan\frac{\pi}{l}(y-y_0)=\frac{\pi(k^2+f^2)}{2f\beta l}$, it vanishes at $y-y_0=\frac{\pm l}{2}$ for the constant Coriolis parameter and at a smaller value of $|y-y_0|$ than $\frac{l}{2}$ for a positive value of β; in other words the stream lines are displaced toward the equator through the influence of the variation in the Coriolis parameter.

The figures (1) and (2) illustrate the distribution of the vertical velocity (17) and that excluding the first term in the first bracket in (17) with the following numerical values:

$g=980\,\text{cm sec}^{-2}$, $\omega=7.29\times10^{-5}\,\text{sec}^{-1}$,

$\sqrt{\frac{A_h}{A_v}}=10^3$, $H=4000\,\text{m}$, $l=2\pi\times10^3\,\text{km}$,

$y_0=0$, $R=6370\,\text{km}$, $k=0.25\times10^{-8}\,\text{sec}^{-1}$,

and the figure 3 illustrates the stream lines with $\sqrt{\frac{A_h}{A_v}}=10^4$ and $k=0.25\times10^{-5}\,\text{sec}^{-1}$. In the figure 4 is represented the vertical struc-

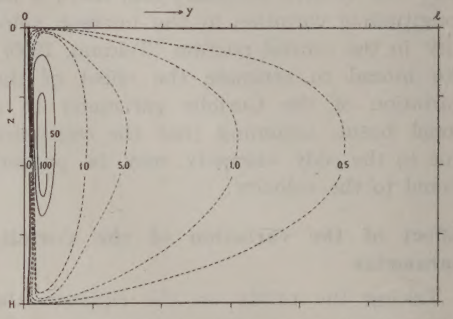


Fig. 1. Distribution of the vertical velocity. unit: $10^{-4}\Delta\rho\,\text{cm sec}^{-1}$; $\sqrt{A_h/A_v}=10^3$, $k=0.25\times10^{-8}\,\text{sec}^{-1}$

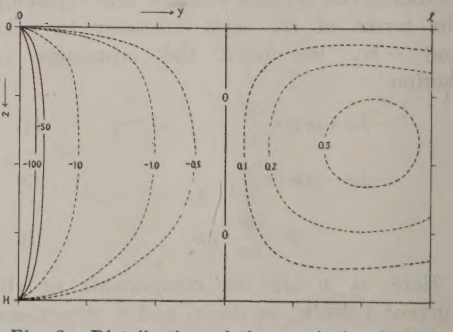


Fig. 2. Distribution of the vertical velocity. unit: $10^{-4}\Delta\rho\,\text{cm sec}^{-1}$; $\sqrt{A_h/A_v}=10^3$, $k=0.25\times10^{-8}$

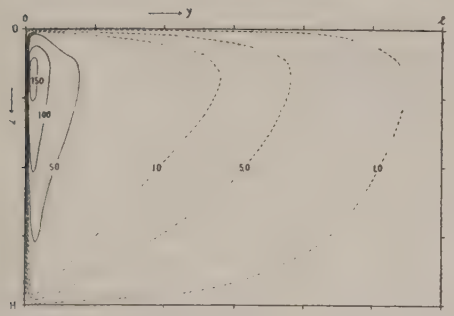


Fig. 3. Stream lines.
unit: $10^5 \Delta\rho$ cm^2 sec^{-1}; $\sqrt{A_h/A_v}=10^4$,
$k=0.25\times10^{-5}$ sec^{-1}

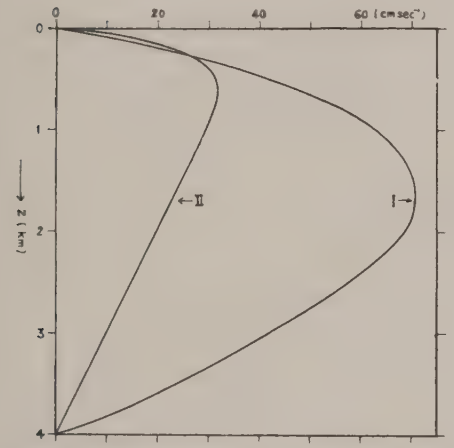


Fig. 4. Vertical structure in the vertical velocity at the equator.
Curve I: for $\sqrt{A_h/A_v}=10^3$ and $k=0.25\cdot10^{-8}$.
unit: $10^3\Delta\rho$ cm sec^{-1}
Curve II: for $\sqrt{A_h/A_v}=10^4$ and $k=0.25\cdot10^{-5}$.
unit: $10^{-2}\Delta\rho$ cm sec^{-1}

ture of the vertical velocity at the equator in the above two cases. The figure 5 illustrates the stream lines for $y_0=\frac{l}{8}$ in place of $y_0=0$ and the other same numerical values as in the above latter case.

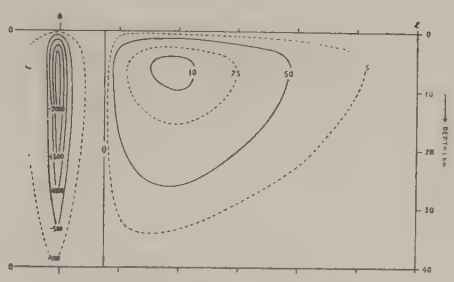


Fig. 5. Stream lines.
unit: $10^5 \Delta\rho$ cm^2 sec^{-1}; $\sqrt{A_h/A_v}=10^4$,
$k=0.25\times10^{-5}$ sec^{-1}

It follows from these results that, in any case the vertical upward velocity increases remarkably in the immediate vicinity of the equator, owing to the decrease of the Coriolis parameter; a constant k exerts an important influence upon the velocity near the equator; in consideration of the variation of the Coriolis parameter the region of sinking extends over the most part in low latitudes and the upwelling is found in the equatorial narrow zone only in the case of the symmetric distribution in the density with respect to the equator ($y_0=0$), and the upwelling is found in more extended region from the vicinity of the equator in the southern hemisphere to higher latitudes in the northern hemisphere in the case of $y_0=\frac{l}{8}$.

Although we have put some assumptions for simplicity, it may be inferred that the variation of the Coriolis parameter causes an intensification of the current in low latitudes.

References

Takano, Kenzo (1955): Note on the convective circulation (1); Records of Oceanographic Works in Japan. (in press).

An Example of the Variation of the Oceanographical Condition of Enshu-nada*

By

Shigeo MORIYASU**

§1. Since 1954 a cold water mass has been observed in Enshu-nada, which is comparable with the cold water mass appearing from 1936 to 1942. Many oceanographers[1)2)] studied the structure of the cold region, and the outline of it has been made clear. The representative oceanographical condition in the appearance of the cold region is as follows: the current axis of the Kuroshio was far away from coast to the south of Shionomisaki and then flowed round the cold region of temperature below 16°C at the depth of 100 m. Such condition was found in 1954 and seems to have continued up to now. But, since the observations were not carried out frequently, it is difficult to see the variation of short period. In Oct. 1954, repeated observations as shown below were made in Enshu-nada, which indicated considerable variations in oceanographical conditions.

Observation A

Date	Stations	
Oct. 2~3	N_1~N_9	operated by Central Meteorological Observatory
Oct. 4~5	H_2~H_9	,,

Observation B

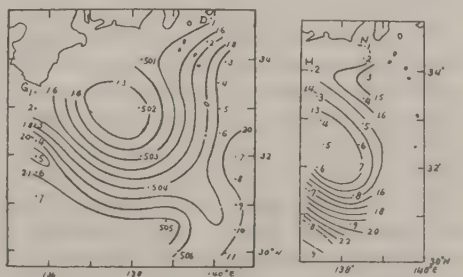
Date	Stations	
Oct. 13~14	501~506	operated by Maritime Safety Agency
Oct. 15~17	D_1~D_{11}	,,
Oct. 19~22	G_1~G_7	operated by Kobe Marine Observatory

In this paper, I intend to show the variation in question using these data.

§2. First we shall show the hydrographical conditions in both observations respectively.

Observation A

The cold region was observed as the area with temperature below 16°C and 10°C at the depth of 100m and 200m respectively in lat. 31°40′N to 33°N and long. 137°E to 138°30′E. Between this cold region and the southern warm region, there was a zone with steep gradient in water temperature distribuiton, where the slope of the isotherms in vertical sections was large. In the cold region the upwelling of the isotherms was conspicuous below the depth of 200m and there were less haline waters near the surface. Furthermore, the minimum chlorinity layer was located at shallower depth than in the southern region with haline waters more than 19.20‰ at 100~300m depth. According to the result of dynamical computations, the main current of the Kuroshio flowed along the zone with steep gradient in water temperature distribution and the westerly current induced by a cyclonic vortex was north of the cold region. Between N_2 and N_3, a strong easterly current was found, which seemed to be a branch of the Kuroshio. Current velocity in the main current was more than 30 cm/sec at the depth of 600m at which minimum chlorinity layer was located, but below this depth the current was weak.

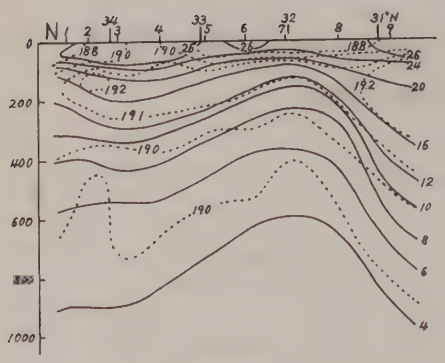


(b) Observation B (a) Observation A

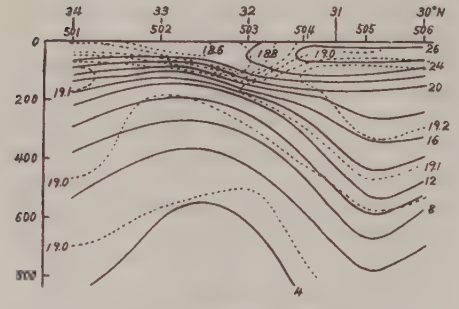
Fig. 1. Location of observation stations and geopotential topography of the sea surface referred to the 800-decibar surface.

* Received Aug. 3, 1955.

** Kobe Marine Observatory.

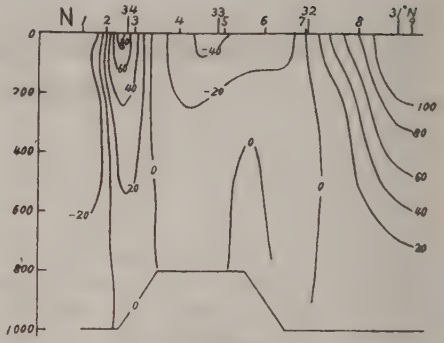


(a) Observation A

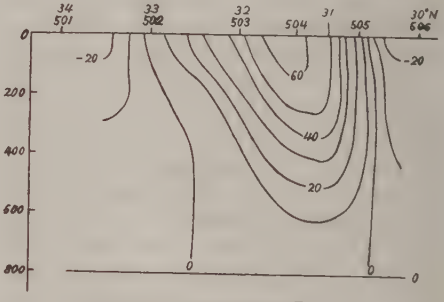


(b) Observation B

Fig. 2. Vertical distributions of water temperature (full line) and chlorinity (broken line).



(a) Observation A



(b) Observation B

Fig. 3. Vertical distributions of current velocity obtained by dynamical computation (cm/sec). Positive values mean the eastward flow.

Since such state was seen as common one, the thickness of the portion with strong current was small in the cold region, while it was large south and north of that region. From the above, it is deduced that the Kuroshio flowed in lat. 31°~32°N south of Enshu-nada and the value of the current velocity was considerably large.

Observation B

The cold region and the main current of the Kuroshio seems to have been displaced northward compared with the case of observation A judging from water temperature distribution. However, the general situation that the warm region was bsoerved south of the Kuroshio which flowed round the cold region and so on, was similar to that in the observation A. The value of chlorinity near the surface in the cold region was about 18.50‰ and decreased by about 0.20‰. The current velocity decreased in general and was about a half of that in observation A. This fact is to be expected from the decreasing in the slope of the isotherms, because the density in this sea area depends mainly upon water temperature. The strength of the cyclonic vortex around the cold region seems to be weaker considering from geopotential topography. Off Shionomisaki, the current axis was located in lat. 32°30′N and the Kuroshio flowed southeastward with maximum velocity above 1m/sec which is more than that off Omaesaki, whereas the breadth of the portion with strong current was less.

§3. As stated above, the cold region and the Kuroshio were displaced northward and the current velocity decreased during about 10 days. Since Sections N_1~N_9 and 501~506 were nearly in long. 138°15′E, it is significant to compare both vertical sections. If we assume that the distance of vertical displacement determined from the distribution of density *in situ* represents the real

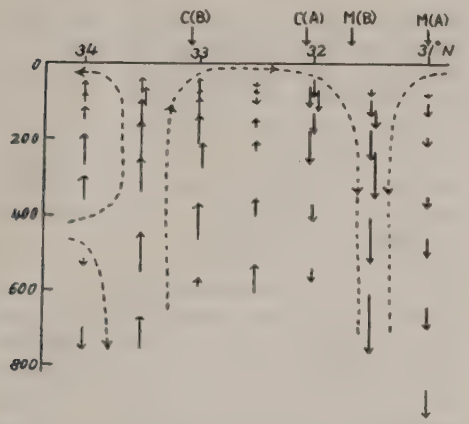


Fig. 4. Distribution of the vertical displacement of the isosteres in the section.
C(A) : center of the cold region in obs. A
M(A) : main current of the Kuroshio in obs. A

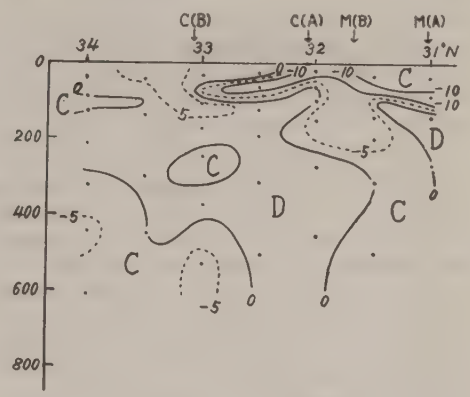


Fig. 5. Distribution of horizontal divergence in the section. (unit: $\times 10^{-7}$ C.G.S.)

value, the mean vertical motion within the period can be obtained. The difference of the depth of the isosteres in the section is shown in Fig. 4, which indicates that ascending and descending motions existed north and south, respectively of the center of the cold region in observation A. Therefore the circulation shown by dotted lines is deduced in the vertical section. The ascending motion was conspicuous near the center of the cold region in the observation B, while the descending one was remarkable near the current axis of the Kuroshio in the observation B. The maximum value of the distance was about 160m in lat. 31.5°N and the velocity corresponding to that was 16.8×10^{-5} cm/sec.

Next, horizontal divergence is computed from equation of continuity by using the above data. Since $\frac{\partial w}{\partial z}$ is to be obtained from the distribution of vertical velocity, horizontal divergence is obtained as $-\frac{\partial w}{\partial z}$. The distribution of horizontal divergence shown in Fig. 5 indicates that above the layer of 100m depth convergence was remarkable south of lat. 32.5°N, and divergence was observed north of it, while on the contrary, below the depth of 100m the southern and northern part there were convergent and divergent area, respectively. But a little conspicuous convergent region was seen below the depth of 400m north of lat. 33°N.

Though the vertical motion in deeper layers can not be known, the relation among the variation of the oceanographical condition, the vertical motion and the horizontal divergence is considered. In a cyclonic vortex around the cold region in observation A, downward motion and convergence near the surface were seen as expected. The descending motion developed south of the center of the cold region and was very weak north of it, although the region was approximately axial-symmetric. However, convergence above the layer of 100m depth was also conspicuous north of the center. It was made clear that in observation B chlorinity was low in lat. 32°~33°N by the influence of converging less haline waters, which were transported downwards and decreased chlorinity at 100m depth in lat. 32°N. Furthermore, steep horizontal gradient between the less haline and more haline waters from south was in the convergent region north of the main current of the Kuroshio in observation A. In general, the values of convergence and divergence were large above the layer of 200m depth, but there was a little large convergent region below the depth of 400m in the northern portion. In observation B, the center of the cold region was located in lat. 33°N where upward motion was predominant, and

the main current existed in lat. 31°40′N where downward motion developed. It was made clear by many oceanographers that the appearance of the cold region is due to upwelling of deeper waters. Though we can not identify the appearance with the displacement, the latter seems also to be closely related to vertical motion. Accordingly, it is deduced that, in the cold region convergent was predominant near the surface by a cyclonic vortex and descending motion developed, but the region was displaced towards the divergent area with descending motion.

§4. The author has discussed the variation of the oceanographical condition in about 10 days off Enshu-nada and considered the displacement of the cold region. A theoretical consideration will be given in another paper.

Finally, the author expresses his hearty thanks to Mr. Y. Fujii and Mr. T. Ichie for their kind advice and encouragement, and to Mr. Y. Shimomura for his assistance in preparing manuscript.

References

1) M. Uda: On the recent anomalous hydrographic conditions of the Kuroshio. Rep. Imp. Fish. Inv. St. No. 10, 1940.

2) T. Ichie: On the variation of oceanic circulation (VI). Geophys. Mag. Vol. 25, No. 3~4, 1954.

An Attempt to Predict the Surface Temperature of the North-Eastern Sea Adjacent to Japan for the Summer, 1955*

By

Nobuo WATANABE and Toshiyuki HIRANO****

On the basis of data observed since 1921, the authors previously studied the fluctuation in sea conditions in the area adjacent to Japan during three to 12 months ending in March 1955 to compare them with those of every coordinate period. Some of important subject matter in the study were: changes in the surface temperature in the North-Eastern Sea; the resemblance among the changes in different seasons and years; analysis of the water masses of the Kuroshio and Oyashio in the neighborhood to Hokkaido; the seasonal or annual change in the water mass distributions during the period under study.

A prediction which could be extended from the results of the study and made public in April 1955 is:

That in the summer of 1955 the surface temperature in the northern subarea of the North-Eastern Sea of Japan will likely be lower than of the normal summer. However, in the waters more southerly than the middle region, there is a strong probability of having the surface temperature a little higher than, or to say in the least, similar with, that of the normal summer.

The present paper has prepared in order to explain as to by what means the prediction was made possible. On this occasion the authors wish to acknowledge our indebtedness to Dr. M. Uda for his kind advices to our work, and wish to extend their heartfelt thanks to all the members of the Oceanographical Section, Tokai Regional Fisheries Research Laboratory, who collaborated with them in attaining the above results.

* Contribution B. No. 221 from the Tokai Regional Fisheries Research Laboratory. Received Aug. 3, 1955.

** Tokai Regional Fisheries Research Laboratory, Tokyo, Japan.

Basis of the Prediction

(I) *Degreess of Resemblance*

a) *Resemblance in the seasonal or annual Progress of the Changes*

Fig. 1 shows the Sea District under study divided into four subareas bounded by latitudes and longitudes as follows:

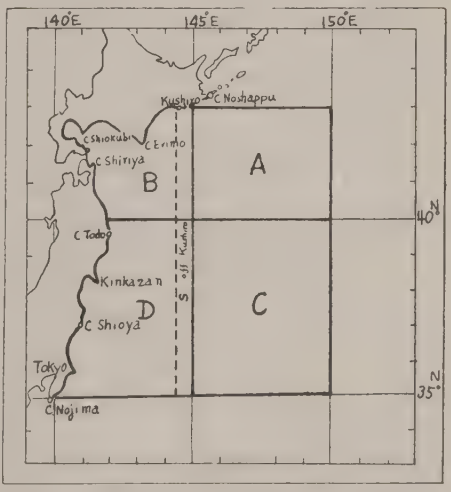


Fig. 1. Subareas and regular oceanographic stations in the North-Eastern District.

	Subarea	Latitude N	Longitude E
A)	Northern Offshore	40°—43°	145°—150°
B)	Northern Inshore	40°—43°	145°—Shore Line.
C)	Southern Offshore	35°—40°	145°—150°
D)	Southern Inshore	35°—40°	145°—Shore Line.

As a comparison between the temperatures at definite moments is not supposed to be

Table 1. Comparison of the continuous surface temperature changes in the current period with the coordinates since 1933. (Period: 12 months ending on March 31.)

x_i: Degree of resemblance on the basis of the period of 1954–55.

$\Delta\theta$: Deviation of the temperature in the following summer from the mean temperature of the coordinate seasons.

The notations read likewise in Tables 1 to 3.

Year	A		B		C		D	
	x_i	$\Delta\theta$	x_i	$\Delta\theta$	x_i	$\Delta\theta$	x_i	$\Delta\theta$
1933~34							(1.7)	−0.2
1934~35			1.6	−2.3			3.0	−1.5
1935~36			(2.0)	−0.9			2.3	−1.1
1936~37			1.6	−0.1			1.8	+0.9
1937~38			2.2	+1.4	2.5	−0.4	1.8	+0.3
1938~39								
1939~40								
1940~41			(1.5)	−2.6	1.6	−0.5	2.2	−1.2
1941~42			(5.8)	+3.1			3.1	+0.9
1942~43					(2.9)	+0.5		
1943~44								
1944~45								
1950~51					2.4	−0.1	1.7	0.0
1951~52	(2.5)	+0.3			1.2	+0.1	1.8	+0.3
1952~53	(3.3)	−1.2			1.9	+0.1	1.6	−0.3
1953~54	(2.1)	−1.5	(3.4)	−0.1	1.8	+1.2	2.6	−1.4

Table 2. Comparison of the continuous surface temperature changes in the current period with the coordinates since 1933. (Period: 9 months ending on March 31.)

See note of Table 1 for the notations.

Year	A		B		C		D	
	x_i	$\Delta\theta$	x_i	$\Delta\theta$	x_i	$\Delta\theta$	x_i	$\Delta\theta$
1933~34					3.3	(−0.3)	(1.7)	−0.2
1934~35			1.5	−2.3	3.2	−0.4	2.3	−1.5
1935~36	(3.0)	−0.9	2.2	−0.9	2.1	+0.2	2.0	−1.1
1936~37	(3.2)	+0.9	1.7	−0.1	2.2	+0.4	1.3	+0.9
1937~38			2.4	+1.4	2.6	−0.4	1.7	+0.3
1938~39					3.0	+0.2		
1939~40					2.5	−0.9		
1940~41			1.4	−2.6	1.4	−0.5	2.3	−1.2
1941~42			(2.0)	+3.1	(1.9)	+0.5	2.6	+0.9
1942~43					3.1	+0.5		
1943~44								
1944~45								
1950~51					2.7	−0.1	1.9	0.0
1951~52	(2.2)	+0.3			1.1	+0.1	1.9	+0.3
1952~53	(3.5)	−1.2			2.1	+0.1	1.8	−0.3
1953~54	(2.3)	−1.5	(3.6)	−0.1	2.0	+1.2	2.5	−1.4

Table 3. Comparison of the continuous surface temperature changes in the current period with the coordinates since 1933. (Period: 6 months ending on March 31.)
See note of Table 1 for the notations.

Year	A		B		C		D	
	x_ξ	$\Delta\theta$	x_ξ	$\Delta\theta$	x_ξ	$\Delta\theta$	x_ξ	$\Delta\theta$
1933~34							(0.6)	−0.2
1934~35			5.7	−2.3	3.0	−0.4	2.3	−1.5
1935~36	(3.4)	−0.9	2.2	−0.9	1.4	+0.2	2.5	−1.1
1936~37	(3.5)	+0.9	1.7	−0.1	1.7	+0.4	1.1	+0.9
1937~38			2.8	+1.4	4.3	−0.4	1.0	+0.3
1938~39					0.9	+0.2		
1939~40					2.2	−0.9		
1940~41			1.2	−2.6	1.5	−0.5	2.3	−1.2
1941~42			(1.0)	+3.1	(1.4)	+0.5	2.7	+0.9
1942~43					(2.4)	+0.5		
1943~44								
1944~45								
1950~51					1.2	−0.1	0.8	0.0
1951~52	2.4	+0.3			1.1	+0.1	1.4	+0.3
1952~53	(4.1)	−1.2			1.2	+0.1	1.5	−0.3
1953~54	(2.8)	−1.5	(4.2)	−0.1	1.2	+1.2	2.7	−1.4

Table 4. Comparison of the continuous surface temperature changes in the current period with the coordinates since 1935. (Period: 3 months ending on March 31.)
x_ξ: Degree of resemblance on the basis of 3 months ending in March 1955.
$\Delta\theta$: Deviation of the temperature in the following summer from the mean temperature of the coordinate seasons.

Year	A		B		C		D	
	x_ξ	$\Delta\theta$	x_ξ	$\Delta\theta$	x_ξ	$\Delta\theta$	x_ξ	$\Delta\theta$
1934								
1935			2.0	−2.3	2.9	−0.4	2.6	−1.5
1936	3.9	−0.9	2.0	−0.9	1.8	+0.2	2.4	−1.1
1937	2.7	+0.9	1.9	−0.1	1.9	+0.4	1.0	+0.9
1938			2.7	+1.4	1.6	−0.4	1.1	+0.3
1939								
1940								
1941			(1.2)	−2.6	2.1	−0.5	3.0	−1.2
1942			(0.6)	+3.0			3.9	+0.9
1943								
1944								
1945								
1951					1.5	−0.1	0.8	0.0
1952	4.5	+0.3			1.0	+0.1	1.8	+0.3
1953	(4.3)	−1.2			1.5	+0.1	2.0	−0.3
1954	0.7	−1.5	(5.2)	−0.1	1.3	+1.2	3.6	−1.4

Throughout Tables 1-4 the values in parentheses are not always satisfactory in accuracy.

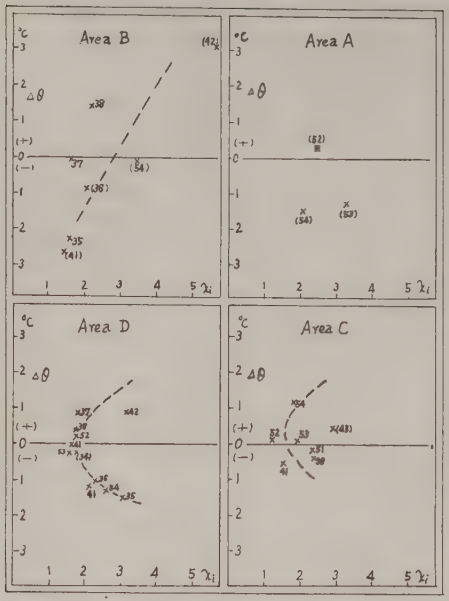


Fig. 2. Spring to winter for 12 months ending on March 31.

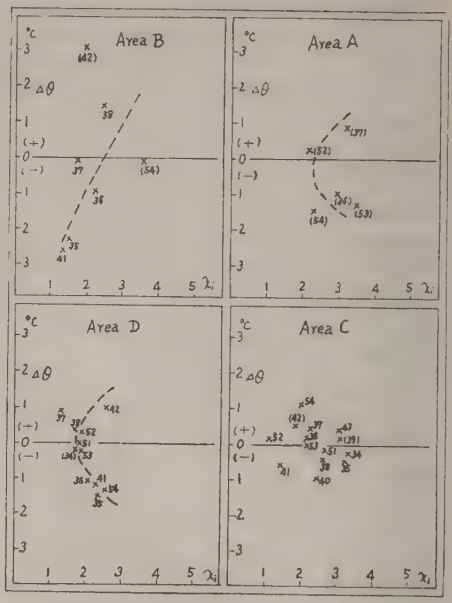


Fig. 3. Summer to winter for 9 months ending on March 31.

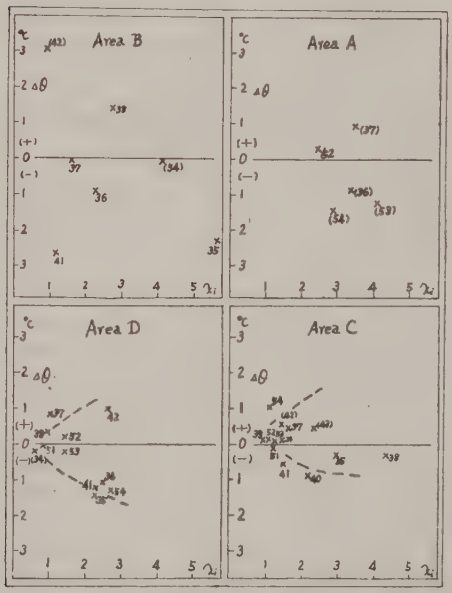


Fig. 4. Autumn to winter for 6 months ending on March 31.

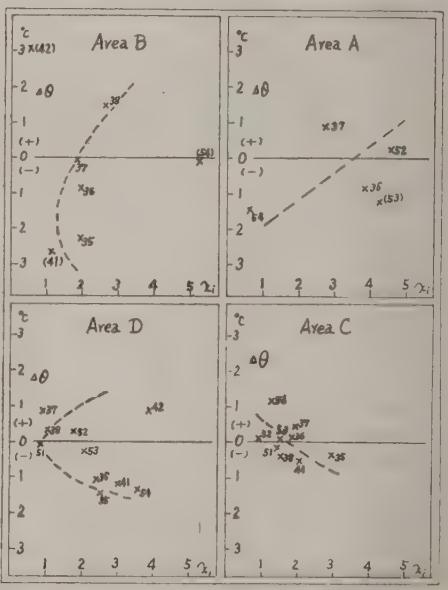


Fig. 5. Winter for 3 months ending on March 31.

Fig. 2–5. x_i between the current period and the coordinates and $\Delta\theta$ in the following summer. Numeral at the plot in Figs. 2–4 indicates the later year in each period of 6, 9 or 12 months ending in March and those in Fig. 5 indicate the year. The values plotted at the numeral enclosed in parentheses are not always satisfactory in accuracy.

feasible for confirming the resemblance of the continuous fluctuations in coordinate seasons of different years, the temperatures continuously changing for different length of months ending in March 1955 have been compared with those of the same seasons from April 1933 to March 1954, on the basis of the monthly mean temperature calculated for each subarea in the period.

The degree of resemblance[1] may be computed by

$$x_i = \sqrt{\frac{\sum (\theta_i - \theta_0)^2}{n}}$$

where θ_i: the temperature on i-year.
θ_0: the temperature of the 1954–55 period.
n: the number of years adopted in the computation.

Four different lengths of seasons used for the study are: 12 months from spring to winter of the following year; 9 months from summer to the following winter; 6 months from autumn to the next winter; 3 months for the winter. (Throughout the present study, the calendar year divided into seasonal quarters begins with winter in January and ends in autumn in December.)

The correlations between the resemblances and the temperature anormalies in the summer following the season for which the degree of resemblance (x_i) was computed are shown in Figs. 2–5. It may be seen from the figures that in some of the past summer seasons the deviation from the mean temperature is almost negative in the northern subareas, and that such a type of summer come following the season when the temperature progression resembles to that of the coordinate season during April 1954 to March 1955.

In the southern subareas, however, the deviation from the mean temperature is either positive or approximate to zero. From these analogies the authors concluded, as stated before, *that the temperature in the northern subareas would be lower in the 1955 summer than in the normal year, but in the southern subareas it would be warmer or normal in the coming summer.*

b) *Resemblance of temperature change at coastal stations*

Of many stations regularly occupied in the North Pacific coast since 1921 five at the localities indicated in Fig. 1 have been chosen for the present study. The temperature progressions at these stations during six months ending in March 1955 have been compared with the coordinates in the

Table 5. Degree of resemblance between continuous surface temperature changes of the current period and the coordinates at coastal stations since 1921. (Period: 6 months ending on March 31.)

Year \ St.	C. Noshappu	C. Shiokubi	C. Todo	C. Shoya	C. Nojima
1921~22	3.0	2.3	2.2	2.2	4.4
1922~23	2.7	2.3	1.2	3.5	3.8
1923~24	1.9	2.6	2.5	2.3	4.3
1924~25	2.4	2.9	1.7	2.6	4.3
1925~26	2.2	1.3	1.1	2.9	3.8
1926~27	2.2	1.4	1.1	2.7	2.1
1927~28	2.5	1.6	0.9	3.1	3.7
1928~29	3.3	2.2	1.5	3.1	3.7
1929~30	2.6	1.6	1.5	2.4	3.4
1930~31	2.9	2.2	1.3	2.7	3.4
1931~32	2.2	2.8	1.4	2.9	3.3
1932~33	1.9	1.5	1.1	2.4	4.0
1933~34	2.2	1.4	1.8	3.1	4.8
1934~35	2.1	2.8	2.8	2.8	5.0
1935~36	2.5	1.9	1.4	3.4	4.9
1936~37	2.4	1.1	1.1	3.2	4.7
1937~38	2.3	1.6	1.1	2.9	4.9
1938~39	2.9	2.1	1.1	1.8	3.8
1939~40	2.8	2.1	1.4	2.5	4.4
1940~41	2.4	1.2	1.4	2.4	4.2
1941~42	2.0	1.4	1.4	1.9	4.3
1942~43	2.4	1.5	1.4	2.7	4.7
1943~44	3.1	2.5	2.6	2.9	4.1
1944~45	2.9	2.6	2.9	3.3	4.6
1945~46	2.5	2.4	—	2.7	
1946~47	2.6	0.7	1.4	3.3	6.3
1947~48	2.3	1.2	1.7	2.1	3.7
1948~49	2.8	1.2	1.4	2.3	3.2
1949~50	3.0	1.1	1.7	2.6	3.8
1950~51	2.4	1.3	0.9	2.1	4.0
1951~52	2.5	1.0	1.1	2.1	3.6
1952~53	2.9	1.2	0.8	2.5	3.8
1953~54	3.0	1.2	1.3	2.3	4.6

years after 1921 inclusively.

Indicated in Table 5, the degrees of resemblance in the coastal area are not so clear as in the offshore areas. Nevertheless, what can be interpreted from the table is this. In the 1954–55 period the temperature change in the coastal waters north of Todo-Zaki was, more conspicuous than the southern coasts, similar to that of the years when the summer temperature was lower than usual.

But in other cases, the temperature in the northern areas followed the fluctuation as same as that of the season preceding to a warmer type of summer.

In the coastal region south of Shioya-Zaki, the temperature of the current season resembled those past seasons ahead of a warmer summer more than those followed by a colder summer. In the south of Nojima-Zaki the resemblance to the coordinate seasons are very bad before a colder summer but large before a warmer summer. The comparison has led the authors to a forecast: *that in the coastal region north of Todo-Zaki the temperature anomaly in the coming summer will be remarkable in view of strong deviation from the mean temperature in that area, though it cannot be made certain whether the temperature will turn higher or lower. On the other hand, rather high temperature will probably occur in the southern waters of Nojima-Zaki.*

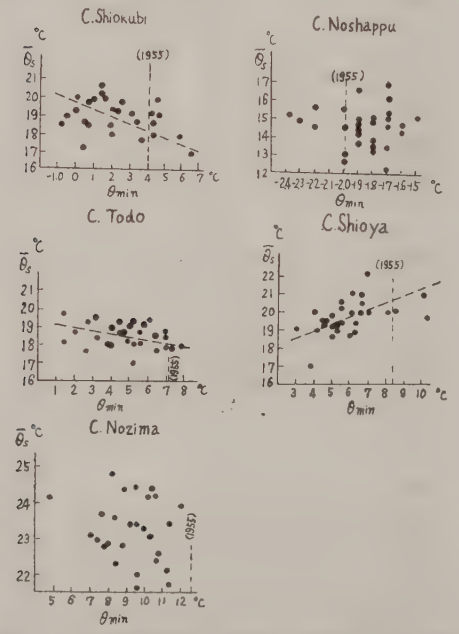


Fig. 6a. Relationship between minimum winter temperature and mean temperature for the following summer.

(II) *Prediction by Correlation*

On the basis of data of the same period as used in computing resemblances of the temperature progression, the correlation between the temperature of different seasons at the five coastal stations has been studied.

a) The correlation diagrams between the absolute minimum of winter temperature and the mean temperature of the next summer at the five stations are in Fig. 6-a. Although being rather obscure both at Noshappu-Zaki and at Nojima-Zaki, the correlation is fairly clear and negative at Shiokubi-Zaki and Todo-Zaki, but positive at Shioya-Zaki. When the minimum tempera-

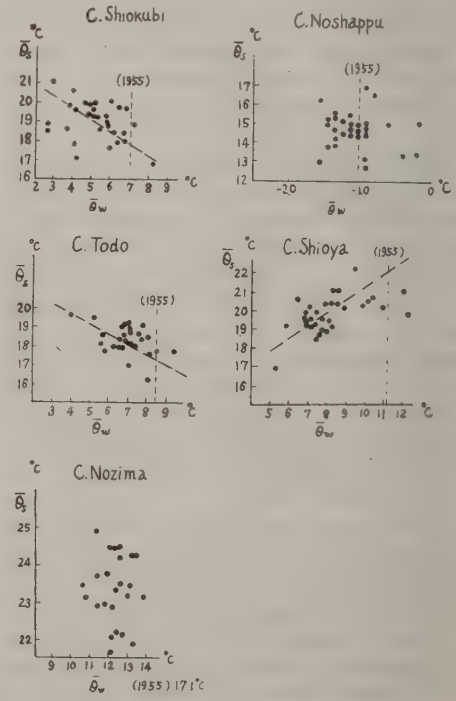


Fig. 6b. Relationship between mean temperature of winter and the following summer.

ture of the 1955 winter is put into the diagram, the temperature fluctuation in the coming summer might be foreseen like this.

In correspondence with the minimum temperature of last winter, *the mean temperature of the 1955 summer will be lower in the north of Todo-Zaki, and normal or a little higher in the neighborhood of Shioya-Zaki.*

b) In Fig. 6-b is the correlation between the mean temperatures of the winter and the following summer at these stations; the correlation coefficients between the temperatures of different seasons at four stations in Table 6. From these results it may be said that the mean temperature of the winter and the next summer are likely related in the same manner as stated in the foregoing paragraph (a), *i.e.*, inversely in the northern subareas, but positively around Shioya-Zaki. The mean temperature observed last winter at the stations are:

Station	Temperature C°
Noshappu-Zaki	7.0
Todo-Zaki	8.5
Shioya-Zaki	11.2
Nojima-Zaki	17.1

Table 6. Correlation coefficients of mean surface temperature.

Corr. Coefficient	St.	C. Noshappu	C. Shiokubi	C. Todo	C. Shioya
Simple Corr. Coefficient	$r_{1,2}$	+0.220	−0.119	−0.102	+0.596
	$r_{1,3}$	−0.300	−0.421	−0.423	+0.589
	$r_{1,4}$	+0.036	−0.049	−0.411	+0.180
	$r_{2,3}$	+0.327	+0.552	+0.728	+0.816
	$r_{2,4}$	+0.041	−0.353	−0.092	+0.247
	$r_{3,4}$	+0.015	+0.138	+0.246	+0.439
Partial Corr. Coefficient	$r_{12,34}$	+0.352	+0.189	+0.221	+0.218
	$r_{13,24}$	−0.416	−0.448	−0.445	+0.226
	$r_{14,23}$	+0.031	+0.104	−0.249	−0.071
	$r_{12,3}$	—	—	—	+0.247
	$r_{13,2}$	—	—	—	+0.221
	$r_{23,1}$	—	—	—	+0.717
Multiple Corr. Coefficient	$r_{1,234}$	+0.443	+0.452	+0.597	+0.617
	$r_{1,23}$	—	—	—	0.607

Note: Suffixes 1, 2, 3 and 4 represent summer, spring, winter and autumn, respectively.

It may be expected, therefore, that *the temperature in the coming summer would be lower in the northern coast of the district but higher in the coast south of Shioya-Zaki.*

(III) *Prediction by the Analysis of Water Masses*

a) *The Isentropic Analysis of the water masses South off Kushiro*

Since 1936 the water mass distribution in the sea off Kushiro has been observed by the R. V. Sōyō-Maru, Tankai-Maru, and Tenyō-Maru. Using data from the observations, mixing ratios of the Oyashio and Kuroshio water on the vertical plane along the fixed line (Fig. 1) have been computed by quasi-isentropic analysis.[2] Prepared in Figs. 7 and 8 were the distribution pattern of March 1955, and the comparison of the current month with the coordinate months in the past, respectively.

It has been known that the upper layer from the surface to a depth of about 200 meters in an area 100 miles south off Ku-

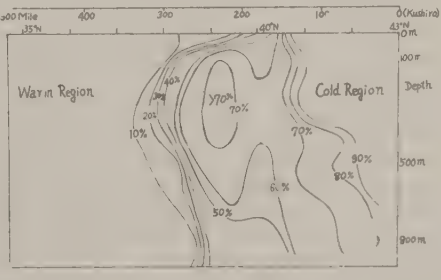


Fig. 7. Vertical distribution of warm and cold currents on the line of Long. 44°20′E for 500 miles S off Kushiro, March 1955. (Based on quasi-isentropc analysis.)

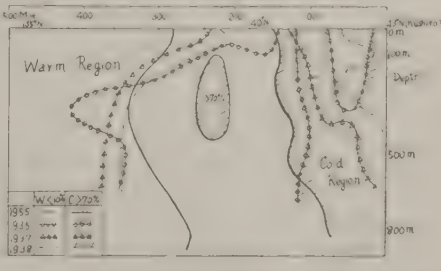


Fig. 8. Comparative distribution of warm and cold currents off Kushiro between March 1955 and coordinates of 1935, 37, 38.

shiro is mostly covered by the Oyashio water. (The term Oyashio water is here defined as a body of sea water which contains 70% of the pure Oyashio per unit of area.) The factors which have been computed in order to determine the influence of the cold current for the winter and the summer during the years under discussion are

$R'=\frac{\Sigma RS}{\Sigma S}$....Mixing ratio of the Oyashio water,

$\bar{\theta'}=\frac{\Sigma \theta RS}{\Sigma RS}$...Mean temperature of the same,

$\bar{\theta}=\frac{\Sigma \theta S}{\Sigma S}$.....Mean temperature in the vertical section under study,

where θ: temperature in degrees of Centigrade,

R: mixing ratio of the Oyashio water computed by the quasi-isentropic analysis,

S: an area in an arbitrary untit.

Here are the assumption developed from the results.

i) R' in August is inversely correlated both with θ' and with $\bar{\theta}$ in March. In other words, when the temperature of the Oyashio in March is lower in the sea off Kushiro, the inflow of the Oyashio water to the area is great. Comparing with the conditions in every coordinate month past, and in last March are so remarkably low just as R' is so great.

These findings may validate views that the influence of the Oyashio water in winter (three months ending in this March) must have been predominant over the area, and that *the inflow of the Oyashio water to the area would possibly be larger in the summer of 1955* (Refer to Table 7).

ii) The results from the water mass analysis for the vertical section mentioned above (Fig. 8) have enabled the authors to assert that the Oyashio water in the area had to flow southward more powerfully in last March than it did in the same month of 1935. However, the northern limit of the Kuroshio on the upper layer seems to have located more northerly deviating in the last winter than in the 1935's winter, and prevailed as strong as it did in 1937 and 1938. From this it would be most probable that Oyashio and Kuroshio prevailed last winter in this part of the Pacific, with the former predominating in its southerly flowing through the northern part, while the latter forcefully flowing up north along the waters south of the intermediate area of the region. Since in the southern offshore of the district the temperatures in the winter have been found positively in correlation with those of the following summer, *the inflow of the Kuroshio in the present summer is expected to be as powerful as it was last winter.*

Putting all the findings together, it may be concluded *that the surface temperature of the sea district in the current summer will be lower in the northern subareas than it was in the normal year. In contrast, the southern subareas will have the temperature either higher or normal, but not likely lower than the average summer.*

Table 7. R', θ' and θ in the upper layer (0-200m) in the area covering 100 miles south off Kushiro.

Year \ Month	R' %				θ' °C				θ °C			
	1	2	3	8	1	2	3	8	1	2	3	8
1936	82	82	—	87	2.3	1.9	—	2.9	2.3	2.0	—	3.0
1937	—	—	87	48	—	—	2.1	5.0	—	—	2.0	6.6
1938	—	—	66	56	—	—	3.0	4.4	—	—	3.3	5.5
1939	—	—	86	70	—	—	1.2	4.0	—	—	1.2	4.5
1940	—	—	84	77	—	—	1.2	4.1	—	—	1.3	4.2
1941	85	—	91	72	2.2	—	0.7	4.3	2.3	—	0.8	4.5
1955	—	—	96		—		0.4		—	—	0.4	

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海洋観測における索の長さの補正について*

秦　　克　己**

On the Correction of Wire Length in Oceanographical Observations

By

K. HATA

Abstract: The depth measured by the unprotected thermometer sometimes does not agree with the expected depth, owing to the inclination of the wire caused by current and wind. The author has tried to get an experimental formula which enables to estimate the depth of the sampling bottle by means of measuring the wire length and the angle between the wire and the vertical above thesea-surface, and he got the following formula;

$$D=l\cos\theta-C\theta^{n}$$

where D, l, and θ are depth, wire length and angle respectively; C, n are constants which vary with the depth (600, 800, 1200, 1500 m).

As illustrated in the figure (Fig. 2), the results of estimation are very satisfactory for practical purpose.

1. 緒　　言

海洋観測を実施する場合には，現在 200 m 以深に被圧転倒温度計を附して採水・測温した層の深さを決定しているが，海流又は風によつて観測船が流されて索が傾斜し採水器が所要の層に達しない場合が非常に多い．この場合に船上で測る索の傾斜角によつて採水器の所要の層に達する様に索を延ばす事が必要である．

之に関聯して日高[1]・福富[2]両博士及び最近では菱田[3]・市栄[4]両博士に依つて検討されてきたが，筆者は昭和 24 年以降当台で実施してきた夕汐丸の観測結果，即ち索の傾斜角より被圧転倒温度計に依る深さ，その時の索の長さ，傾斜角より実験式を求め，これに依りその延ばし方を算出した．

尚この調査の中間報告として昭和27年9月第2回東北海区海洋調査技術連絡会の際に発表したが，その後一応取りまとめたのでこゝに報告する。

2. 索の傾斜角より所要の層迄延ばす索の長さを求める実験式

海流の流動状態は極めて複雑であつて理論式で求めるより実験結果即ち海洋観測結果より実験式を求めた方が良いと思われる．

300 m 以浅を観測する場合は $l\cdot\cos\theta$ (l はその時の索の長さ，θ は傾斜角) にて補正すると大体実測と一致する．これは索の傾斜は一定で直線に近い値を示していると思われる．それでこの調査は 600, 800, 1000, 1200, 1500 m の 5 層に分けその各層毎に調査した。但し流れが極めて複雑な地点即ち黒潮と親潮，津軽暖流と親潮の収斂線の高温側では時としては 3～4 節の非常に速い流れが見られこの様な特異点はこの場合多くの資料の中か

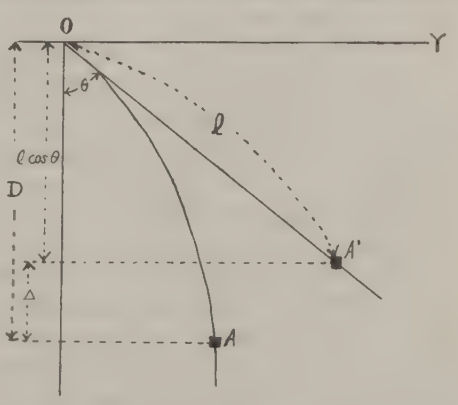

Fig. 1. Schematic representation of wire form under the sea surface and notations used in the Eq. (1).

* 1955 年 6 月 14 日受理

** 函館海洋気象台 Hakodate Marine Observatory

らはぶき後日の調査に待つ事とした。

第1図に示す如く O は観測点，OY は海面，A は採水器，OA は索の長さ l，その時の傾斜角を θ，OA' は角度 θ で l を直線に延ばした場合その時の深さを D（被圧転倒温度計に依る）とすれば

$$D=l\cdot\cos\theta+\Delta \qquad (1)$$

$$\Delta=f(\theta) \quad \text{とする。}$$

600, 800, 1000, 1200, 1500 m の各 D に於ける l, θ をとり，(1) より Δ を求めて，各 D 毎に θ と△との関係を対数方眼紙に示すと第2図の如く，直線上にのる。即ち

$$\Delta=c\,\theta^{n} \qquad (2)$$

c, n は各 D に於ける常数

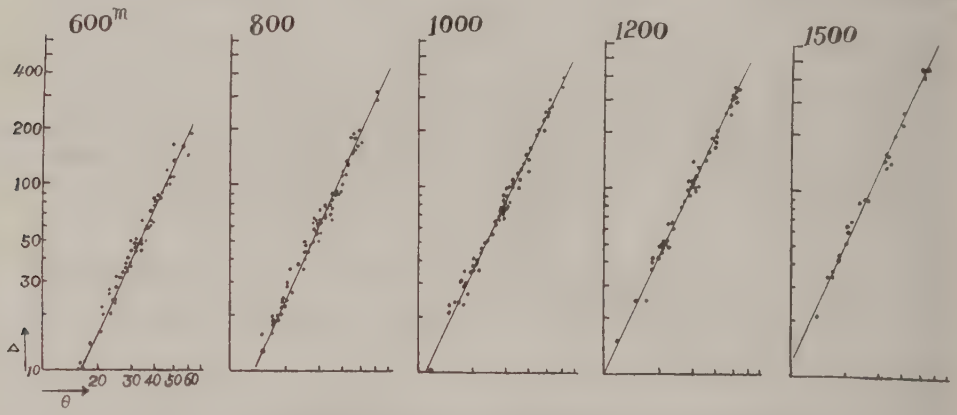

Fig. 2. Relationships between wire angles and correction values.

実際の観測では D は所期の値の附近に分散しているので，次のような補正を行つて D と l との関係を求めた。

海洋観測に際して一つの索に同時に3本の採水器を取りつけ其の時の l=660. 860, 1060 m，被圧転倒過度計に依る深さは D'=510, 688, 876 m となつた場合に之より内挿に依り D=600, 800 m に対する l=758, 979 m となる。

θ と△との関係は第2図に示す如く対数方眼紙上に略直線上にあるが点が多少ばらつきがあるのは索の傾斜角の測定誤差，その傾斜角の変動及び採水器の取りつけた数に依るものと思われる。

(1), (2) より $D=l\cdot\cos\theta+c\theta^{n}$ (3)

c, n は各 D に於ける常数であつて其の値は第2表に示す。

(3)式より θ=10, 15, 20……55, 60, D=600, 800……1500 m に於ける l を算出すると第1表の如くなる。即ち海洋観測に際して索の傾斜角 θ と所要の層 D より l が求められそれにともなつて索の延ばし方が決定される

尚この調査に当り函館海洋気象台長竹内能忠氏並びに元当海洋課長藤井義之氏の御指導を深く感謝致します

Table 1. The values of wire length l for various values of D and θ.

θ \ D	600	800	1000	1200	1500
10	605	806	1006	1206	1507
15	614	815	1017	1216	1521
20	621	825	1027	1230	1536
25	634	840	1041	1245	1553
30	648	856	1061	1267	1580
35	664	873	1081	1290	1602
40	684	897	1103	1315	1637
45	706	921	1132	1350	1678
50	731	950	1169	1392	1722
55	763	987	1212	1438	1777
60	800	1030	1260	1500	1850

D=depth (m) θ=wire angle (degree)
l=wire length

Table 2. The values of c and n in Eq. (2)

D	600	800	1000	1200	1500
n	2.36	2.25	2.15	2.10	2.09
c	0.013	0.028	0.056	0.084	0.111

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The Distribution of Phosphorus in the Waters of the Kuroshio Region (Preliminary Report)*

By

Takeo KAWAMOTO**

The occurrence and distribution of phosphorus in its various forms in the sea are of interest in connection with the productivity of the sea and the water mass analysis. Phosphorus occurs in the sea as inorganic phosphorus and as organic phosphorus in soluble organic form and particulate matter. Most frequently the total organic phosphorus content, which includes both soluble and particulate organic phosphorus, is obtained by determining total phosphorus and subtracting inorganic phosphorus.

Here, a study was made on the character of the water system by the distribution of both inorganic and total phosphorus in sea water samples collecting in the Kuroshio region, in which the observed stations are shown in Fig. 1. The arrow in the figure

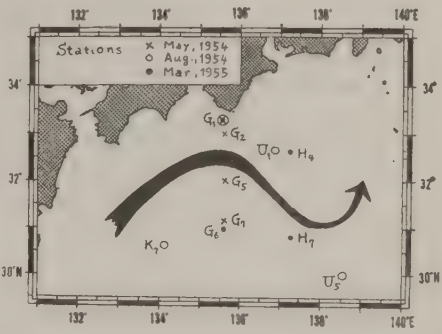

Fig. 1. Positions of hydrographic stations in the Kuroshio region. Arrow indicates Kuroshio current axis, approximately.

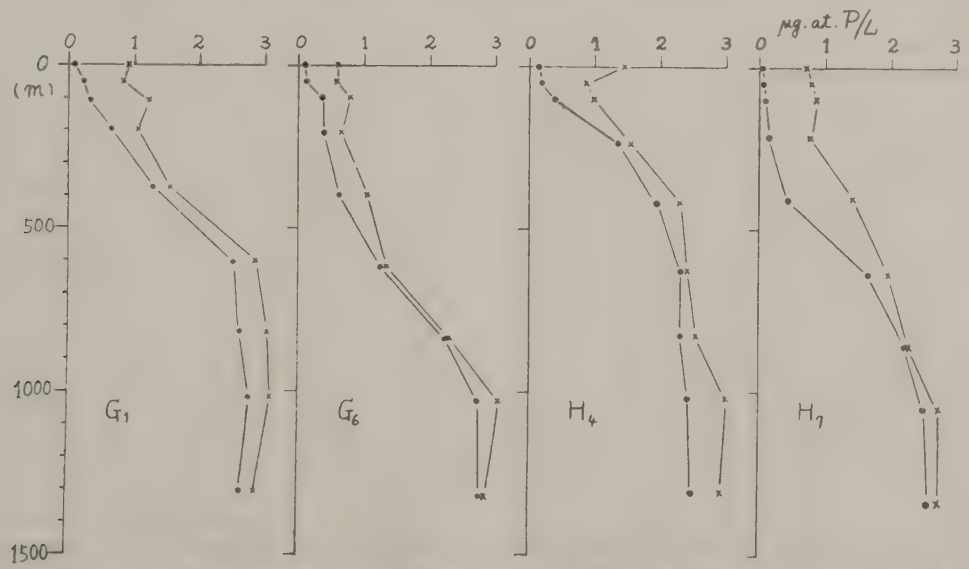

Fig. 2. Vertical distributions of total (○) and phosphate-P (●) in the water column G_1, G_6, H_4 and H_7 in March 1955.

* Received Aug. 3, 1955.

** Kobe Marine Observatory.

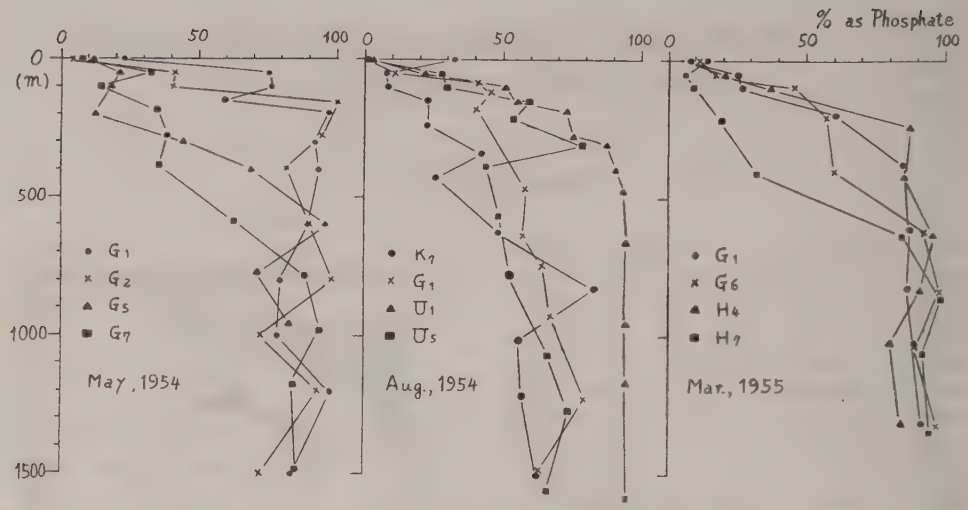

Fig. 3. Vertical distributions in the percentage composition of phosphate-P to total-P in the water column G_1, G_2, G_5 and G_7 in May 1954; K_7, G_1, U_1 and U_5 in Aug. 1954 and G_1, G_6, H_4 and H_7 in March 1955.

indicates the direction of Kuroshio current axis, approximately. Inorganic phosphorus was conveniently determined by a colorimetric method, and total phosphorus was determined by colorimetric estimation after perchloric acid oxidation of organic phosphorus to phosphate, which method was proposed by Hansen and Robinson (1953).

The vertical distributions shown in Fig. 2 are typical one in this area at G_1, G_6, H_4 and H_7 in March 1955. The inorganic phosphorus concentration increased with depth, but the organic phosphorus values (difference between total and inorganic phosphorus) showed no definite correlation with depth. Fig. 3 shows the vertical distributions in the percentage composition of the phosphorus to the total in each column. In this figure, the phosphate in the upper layer (to about 100m) amounts to less than 30% and in the deeper layer (below 500m) more than 80% of the total phosphorus. On the basis of these relations, it seems reasonable to assume that in the upper layer the phosphates are removed and formed labile or stable organo phosphates with organisms and in the deeper layer these organo phosphates are released upon the death of the organisms.

Between 100m and 500m layer, the distributions of the phosphate percentage are irregular at each water column, respectively. The phosphate contents are richer at the northern sea area than at the southern sea area of the Kuroshio current axis. The increase of phosphate concentration in that northern sea area is contributed to the mixing of the surface waters with the phosphate-rich, deeper waters and partly to the land drinage. Especially, the distributions at the stations G_2 in May 1954, U_1 in Aug. 1954 and H_4 in March 1955 show the upwelling conditions at the neighbourhood of the so-called COLD WATER SEA AREA in the Kuroshio region.

As mentioned above, phosphorus can be found in organisms, in particulate and dissolved organic compounds, and as phosphate. The dissolved organic fraction, which can originate as the metabolic product and from the excreta, and the decomposition of organic material must be the intermediate stages in the regeneration of phosphate. Though the total phosphorus was determined in the Kuroshio region, we could not divide the organic phosphorus into the dissolved and particulate phosphorus. As illustrated in the above figures, we are as-

suming that all utilization of phosphate takes place mainly in the upper layer, all utilized phosphate (labile or stable organic form) are decomposed to the inorganic and dissolved organic form in the middle layer, and in the deeper layer inorganic phosphate is regenerated from almost all of organic form.

We will make an attempt to shed light upon the phosphorus cycle in the Kuroshio region, in near future.

Reference

Hansen, A. L. and R. J. Robinson, 1953: J. Mar. Res., **12**: 31-42.

溶在酸素の年変化に関する一考察* (第1報)

永　井　正　男**

A Note on the Annual Variation of Dissolved Oxygen in Sea Water (Part 1)

Masao NAGAI

Abstract: In temperate latitudes the oxygen content of sea water near the surface varies with seasons. This occurs since the solubillity of oxygen in sea water changes with water temperature and further since the production and utilization of oxygen by organisms are not equal in different seasons.

A. C. Redfield estimated the exchange of oxygen across the sea surface ($\triangle Q_E$) and the net production of oxygen by organisms ($\triangle Q_X$) during the period of observations. He concluded that $\triangle Q_X$ is equal to two fifths of $\triangle Q_E$ using the data of oxygen content in the waters of the Gulf of Maine.

In the present paper the auther has made an attempt to determine the magnitude of $\triangle Q_E$ and $\triangle Q_X$ in Gotonada, pointing out the error of Redfield's estimation.

§1. はしがき

海面近くにおける溶在酸素量は季節によつて変化するが，それは酸素の溶解度が水温・塩素量によつて変化するためであり，季節によつて生物による酸素の生産量と消費量とが等しくないためである

A. C. Redfield は 1948 年 Maine 湾における観測資料から，溶在酸素の年変化について，生物活動による正味の生産量は，海面を通して大気中から溶解される酸素量の 2/5 であることを論じているが，著者は第一報において，五島灘の観測資料を使い，彼の研究の誤謬を指摘する

§2. Redfield の研究

A) 今海面 1 m² の下にあつて化学成分の季節的変化がほとんど問題にならないようなある深さまで伸びた水柱を考え，それが海面で大気との交換を除く以外には閉鎖系として取扱うことが出来るということを仮定する。即ちこの水柱の片側から海を通つて運ばれる酸素量は他の側から同じ量だけ出て行くものと仮定し，さらに上昇流や下降流による酸素量の増減は全くないと考える。しかるとき $\triangle Q_O$ をその水柱に存在する二つの観測期間中における酸素量の変化とし，$\triangle Q_E$ は海面を通つて入つて来る量，$\triangle Q_X$ はその期間における生物活動による酸素の正味の生産量とするならば，

$$\triangle Q_E = \triangle Q_O - \triangle Q_X \qquad (1)$$

が成立する。此処で $\triangle Q_O$, $\triangle Q_X$ の負の値はその水柱における溶在酸素の減少をあらわし，$\triangle Q_E$ の負の値は大気中に逃げ去る酸素量を示す

今此等の値を五島灘の資料を使つて実際に計算してみよう。

Fig. 1 には五島灘における観測点 St. 3・4・9

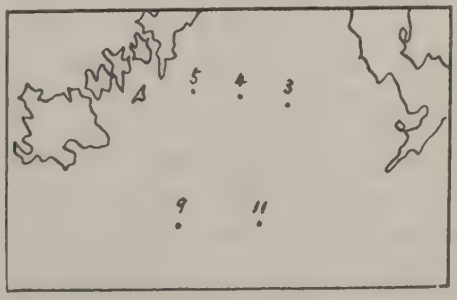

Fig. 1. Fixed points at Gotonada.

St. 3	32-44.6 N	129 27.2 E
St. 4	32-45.5 N	129-17.8 E
St. 5	32-46.8 N	129 08.5 E
St. 9	32-24.0 N	129 06.2 E
St.11	32-24.4 N	129.21.0 E

* 1955 年 7 月 14 日受理

** 長崎海洋気象台, Nagasaki Marine Observatory

Table 1. Seasonal variations of temperature, chlorinity, oxygen content, satuaration value of oxygen and phosphate content in the surface layer of Gotonada, 1951.

	Month	1	2	3	4	5	6	7	8	9	10	11	12
	Day												
	Depth (m)	17~19	6~12	16~22	7~10	17~18	14~17	4~5	28~31	26~28	17~18	6~9	18~19
Temp°C	0	17.1	15.5	16.4	17.4	19.2	21.6	23.1	27.7	25.3	24.3	22.2	17.8
	5	17.17	15.73	16.05	17.18	19.04	21.42	23.11	27.29	25.19	24.16	22.27	17.86
	10	17.12	15.72	16.03	17.10	19.17	21.33	22.86	27.06	25.13	24.12	22.23	17.92
	25	17.10	15.72	15.99	16.82	18.50	20.80	21.81	26.72	25.07	24.29	22.37	17.82
	50	16.79	15.63	15.98	16.51	17.27	18.69	19.88	25.05	24.69	23.62	21.65	17.62
Cl ‰	0	19.01	19.12	19.18	19.14	19.05	18.91	18.68	18.07	18.58	18.70	18.82	18.97
	5	19.01	19.11	19.18	19.13	19.06	18.92	18.68	18.04	18.58	18.67	18.82	18.97
	10	19.00	19.11	19.18	19.14	19.07	18.92	18.68	18.06	18.58	18.68	18.82	18.96
	25	19.01	19.12	19.18	19.13	19.07	19.00	18.84	18.16	18.57	18.64	18.83	18.96
	50	19.00	19.12	19.18	19.13	19.08	19.12	18.99	18.34	18.69	18.69	18.83	18.97
O_2 c.c./L	0	5.49	5.48	5.51	5.59	5.47	5.22	4.93	4.99	4.73	4.82	4.92	5.33
	5	5.46	5.42	5.54	5.68	5.51	5.25	4.86	5.06	4.71	4.81	4.87	5.29
	10	5.44	5.43	5.53	5.58	5.47	5.26	4.90	5.03	4.72	4.85	4.85	5.28
	25	5.40	5.42	5.57	5.78	5.53	5.36	5.09	5.11	4.78	4.88	4.90	5.28
	50	5.43	5.44	5.56	5.58	5.37	5.48	5.21	4.92	4.57	4.64	4.73	5.16
O'_2 c.c./L	0	5.65	5.81	5.71	5.62	5.46	5.23	5.12	4.77	4.95	5.03	5.19	5.59
	5	5.65	5.78	5.75	5.64	5.47	5.26	5.12	4.80	4.95	5.04	5.19	5.58
	10	5.65	5.78	5.75	5.64	5.45	5.27	5.15	4.83	4.96	5.04	5.19	5.57
	25	5.65	5.78	5.75	5.68	5.51	5.32	5.23	4.85	4.97	5.03	5.18	5.59
	50	5.68	5.79	5.75	5.70	5.64	5.49	5.38	4.98	4.99	5.08	5.19	5.60
$O_2/O'_2\times100$ %	0	97	94	96	99	100	100	96	105	96	96	95	95
	5	97	94	96	101	101	100	95	105	95	95	94	95
	10	96	94	96	99	100	100	95	104	95	96	93	95
	25	96	94	97	102	100	101	97	105	96	97	95	94
	50	96	94	97	98	95	100	97	99	92	91	91	92
P_2O_5 γ/L	0	18.9	16.4	18.3	17.2	9.5	8.9	9.2	5.0	2.8	8.1	5.6	7.8
	5	18.4	13.3	20.0	13.9	7.5	6.4	6.7	1.7	1.9	7.8	6.4	6.3
	10	17.0	15.0	18.9	12.2	7.0	9.7	5.5	2.5	2.5	7.0	6.7	8.6
	25	17.3	14.4	20.5	11.4	10.0	5.6	8.3	5.0	1.8	8.3	5.8	8.9
	50	15.1	16.4	22.4	17.2	8.9	6.4	11.8	4.4	4.2	7.2	5.9	10.0

Table 2. Integrated values of oxygen and phosphate in the depths between the surface and fifty meters in Gotonada.

	1	2	3	4	5	6	7	8	9	10	11	12
Q_0 10^3c.c.	270.9	271.3	277.9	285.3	274.4	267.6	253.1	252.8	236.1	241.0	242.9	263.0
$\triangle Q_0$ 10^3c.c.	−14.4	−14.0	−7.4	0	−10.9	−17.7	−32.2	−32.5	−49.2	−44.3	−42.4	−22.3
P_2O_5 mg	853.1	736.3	1029.3	652.3	460.9	316.7	427.6	213.1	117.5	396.6	297.7	435.2
$\triangle P_2O_5$ mg	176.2	293.0	0	377.0	568.4	712.6	601.7	816.2	911.8	632.7	731.6	594.1
$\triangle Q_X$ 10^3c.c.	3.3	5.5	0	7.1	10.7	13.5	11.4	15.4	17.2	12.0	13.8	11.2
$\triangle Q_K$ 10^3c.c.	−17.7	−19.5	−7.4	−7.1	−21.6	−31.2	−43.6	−47.9	−66.4	−56.8	−56.2	−33.5

Column 1. Q_o: Oxygen content of the water column (1 m²×50 m deep) 2. $\triangle Q_o$: variations in Q_o relative to April 3. P_2O_5: inorganic phosphate content of the water column (1 m² ×50 m deep) 4. $\triangle P_2O_5$: variations in P_2O_5 relative to March 5. $\triangle Q_X$: variations in oxygen content corresponding to $\triangle P_2O_5$ attributed to biological activity. $\triangle Q_X = 18.9 \triangle P_2O_5$ 6. $\triangle Q_K$: exchange of the oxygen across 1 m² sea surface. $\triangle Q_K = \triangle Q_o - Q_X$

·11 かかしてある　特に此等の観測点を選んだのは、陸岸水による季節的影響を取りのぞくためと上記の閉鎖系の条件を充すためである。

Table 1 には 1951 年における五島灘の此等 4 観測点における水温·塩素量·溶在酸素量·燐酸塩量の平均値が示してある。

次に生物活動による酸素の正味の生産量 $\triangle Q_X$ は燐酸塩量の変化から推定される。即ち Redfield によれば，燐酸塩 0.373×10^{-3}mg−atom は酸素 1 c.c. の量と等価であり，P_2O_5 1 mg の消失は 18.9 c.c. の O_2 を出現させる。故に

$$Q_X=18.9\ \triangle P_2O_5 \qquad (2)$$

が成立する

Table 2 には 1 m²の表面積を有し，深さ 50 m の水柱における Q_o 及び P_2O_5 の値から，それぞれ $\triangle Q_o$·$\triangle P_2O_5$ を 4 月及び 3 月の Max の値に対して求め，(2) 式より $\triangle Q_X$ を又 (1) 式より $\triangle Q_E$ の値を計算して示してある。

又 Fig. 2 には Table 2 に示してある $\triangle Q_o$·$\triangle Q_X$·$\triangle Q_E$ の値を図示してある。即ち $\triangle Q_o$ の年変化は約 50×10^3 c.c./m² で酸素量の Max は

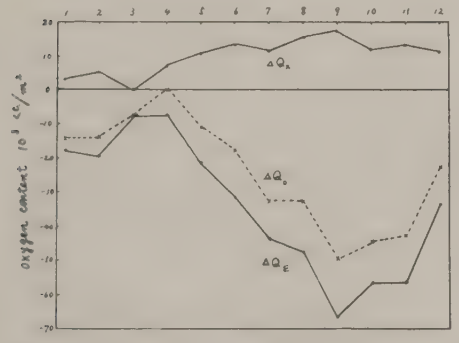

Fig. 2. Seasonal variations of $\triangle Q_o$, the observed variations in oxygen content and $\triangle Q_X$, the estimated variations in oxygen content due to biological activity in a layer between the surface and fifty meters in Gotonada. These values were calculated relative to the content observed in March. The curve $\triangle Q_E$ represents the amounts of oxygen across the sea surface one m² between April and each time of observation.

Negative values indicate the loss of oxygen from sea water.

4 月に，Min は 9 月にあらわれている。又生物活動による酸素の正味の年変化，即ち $\triangle Q_X$ の最大値は 17×10^3 c.c./m² であり，酸素の生産が消費量より多くなる期間は 4·5·6 月であり，7·8·9 月ではほとんど釣合い，10月から 3 月の間では消費量が生産量よりも大きくなる　一方海面を横切る酸素量の年変化即ち $\triangle Q_E$ の極大値は 66×10^3 c.c./m² であり，春から夏にかけて海面から逃れ，冬の間に再び入る　そして変曲点は 4 月の始めと 9 月の終りに起つている。

而して此等の結果より海面を横切る酸素量の約 3/10 が生物活動による酸素の正味の生産量によることが結論される。

B)．一般に酸素は大気中における酸素の分圧と海水中における溶在酸素の張力との差の結果として海面を移動すると考えることが出来る

今海面に接触する空気が水温に等しく，水蒸気で飽和していると仮定するならば，大気中における酸素の分圧 P は $0.21\ (1-w)$ 気圧である。此処に w は水蒸気張力をあらわす　又海水中の酸素の張力 p は海水が大気と平衡状態即ち飽和している時は大気の酸素分圧に等しく，他の状態の下ではそれはヘンリーの法則に従う。即ち C_o を湿潤空気の一気圧と平衡にある海水の酸素量とし，C_x を今問題にしている試水の酸素量とするならば，$p=PC_x/C_o$ である。故に海面を横切る酸素の分圧は次式であらわされる

$$P-p=P(C_o-C_x)/C_o \qquad (3)$$

此処で Redfield は C_o を決定するのに，Fox の O_2 飽和量は乾燥空気による値であるから，これに水蒸気張力 w の補正即ち $1-w/760$ をかけたものを用いなければならないことを強調しているが，朝比奈貞一氏は $w/760$ の値は 0～30 °C で純水の場合には 1～4% であるが，海水の場合にはそれの僅かに 2% 程度で無視しても充分さしつかえないことを計算によつて示している。よつて此処では C_o の値として Fox の飽和量 O_2' をそのまゝ使用することにしたが (1)，Redfield との比較のため水蒸気張力の補正をほどこした C_o の値についても計算した (2)。但し P 及び w の値としてはそれぞれ海上気象の資料による実測値 P_a 及び w' を使用することゝした (Table 3 参照)

Table 3. Estimations of P-p, the pressure of oxygen across the sea surface.

	1	2	3	4	5	6	7	8	9	10	11	12
P_a mb	1023.3	1021.1	1019.9	1016.7	1012.6	1010.7	1009.7	1009.0	1013.3	1015.6	1021.0	1022.0
w mb	8.0	8.7	10.1	12.5	17.3	21.2	29.0	30.5	24.0	16.4	13.1	10.4
P_a-w	1015.3	1012.4	1009.8	1004.2	995.3	989.5	980.7	978.5	989.3	999.2	1007.9	1011.6
P mb	213.2	212.6	212.1	210.9	209.0	207.8	205.9	205.5	207.8	209.8	211.7	212.4
C_o (O_2') (1)	5.65	5.81	5.71	5.62	5.46	5.23	5.12	4.77	4.95	5.03	5.19	5.59
C_x	5.49	5.48	5.51	5.59	5.47	5.22	4.93	4.99	4.73	4.82	4.92	5.33
C_o-C_x	0.16	0.33	0.20	0.03	−0.01	0.01	0.19	−0.22	0.22	0.21	0.27	0.26
$P(C_o-C_x)$	34.11	70.16	42.44	6.33	−2.09	2.08	39.12	−45.21	45.72	44.06	57.16	55.22
P-p mb	6.04	12.08	7.43	1.13	−0.38	0.40	7.64	−9.48	9.24	8.76	11.01	9.88
C_o (2)	5.66	5.80	5.69	5.57	5.36	5.11	4.96	4.61	4.83	4.96	5.16	5.58
C_x	5.49	5.48	5.51	5.59	5 47	5.22	4.93	4.99	4.73	4.82	4.92	5.33
C_o-C_x	0.17	0.32	0.18	−0.02	−0.11	−0.11	0.03	-0.38	0.10	0.14	0.24	0.25
$P(C_o-C_x)$	36.24	68.03	38.18	−4.22	−22.99	−22.86	6.18	−78.09	20.78	29.37	50.81	53.10
P-p mb	6.40	11.73	6.71	−0.76	−4 29	−4.47	1.25	−16.94	4.30	5.92	10.04	9.52

Column. 1. P_a: the atmospheric pressure, mb. 2. w: the tension of aqueous vapor, mb. 3. P_a-w: the pressure of the air, mb. 4. P: the oxygen pressure of the atmosphere. 〔$=0.21\ (P_a-w)$〕 mb. 5. $C_o(=O'_2)$ (1): the oxygen content of the sea watdr in equilibrium with one atmosphere of moist air, c.c./L. (the Fox's saturation values) 6. $C_{o(2)}$: the oxygen content of the sea water in equilibrium with one atmosphere of day air, c.c./L-$\left[\ O'_2\times\left(1-\frac{w'}{760}\right)\right.$, where w is the tension of aqueous vapor in mm. Hg.〕 7. p: the oxygen tension of the water, mb. 〔PC_x/C_o: Henry's law〕. 8. P-p: the pressure of oxygen across the surface, mb. 〔$P(C_o-C_x)/C_o$〕.

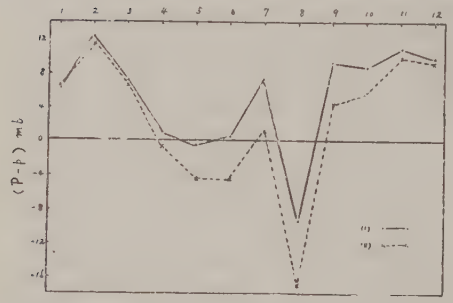

Fig. 3. Seasonal variations in the pressure of oxygen, P-p, across the sea surface of Gotonada. Negative values represent a pressure of oxygen in the water greater than that in the atmosphere, namely a condition being advantageous for the escape of oxygen from sea water to atmosphere.

〔The curve (I) represents the values calculated by the $C_{o(1)}$, and the curve (II) represents the $C_{o(2)}$. Each value of $C_{o(1)}$ and $C_{o(2)}$ are shown in Table 3.〕

Fig. 3 には Table 3 に示した P-p の計算値が図示してある。即ち一見して(II)の方が値が小さいことはうなずかれるが、(I)においては8月の他に5月がマイナスになつているのに反し、(II)においてはさらに4月と6月がマイナスになつており、しかもマイナスの絶対値が明らかに大きくなつていることは後述する如く特に注意を必要とする

C). Redfield はさらに，海面を横切る酸素の交換の割合を次式で示し，交換係数 (Exchange coefficient) なる常数を定義している。即ち

$$dQ/dt=E\cdot S(P-p) \qquad (4)$$

此処で dQ/dt は酸素が海面に入りこむ時の割合，S は表面積，E は比例常数 Exchange coefficient である。即ち E は c.c.O_2/month×m²×atmospheres で与えられる。

Table 4 には Fox の飽和量 O_2' をそのまゝ使用した場合の E の値 (1) と，純水における乾燥空気の補正をしたC_oを使つた場合の E の値 (2)

Table 4. Estimations of the coefficient for the exchange of oxygen across the sea surface of Gotonada.

	1	2	3	4	5	6	7	8	9	10	11	12
	17~19	6~12	16~22	7~10	17~18	14~17	4~5	28~31	26~28	17~18	6~9	18~19
$\triangle t$ (days)	20	30	20	40	30	20	50	80	20	20	40	
$\triangle t$ (months)	0.7	1.0	0.7	1.4	1.0	0.7	1.7	1.0	0.7	0.7	1.4	
$\triangle Q$	−1.8	12.1	0.3	−14.5	−9.6	−12.4	−4.3	−18.5	10.1	0.1	22.7	
$\triangle Q/\triangle t$	−2.6	12.1	0.4	−10.4	−9.6	−17.7	−2.5	−18.5	14.4	0.1	16.2	
(1) $P-p$	6.04	12.08	7.43	1.13	−0.38	0.40	7.64	−9.48	9.24	8.76	11.01	9.88
$(P-p)_m$	9.06	9.76	4.28	0.38	0.01	4.02	−0.92	−0.12	9.00	9.89	10.45	
$E_{(1)}$	−0.3	1.2	0.1	−27.4	−960.0	−4.4	2.7	154.2	1.6	0.0	1.6	
(2) $P-p$	6.40	11.73	6.71	−0.76	−4.29	−4.47	1.25	−16.94	4.30	5.92	10.04	9.52
$(P-p)_m$	9.07	9.22	2.98	−2.53	−4.38	−1.61	−7.85	−6.32	5.11	7.98	9.78	
$E_{(2)}$	0.3	1.3	0.1	4.1	2.2	11.0	0.3	2.9	2.8	0.0	1.7	

Column. 1. $\triangle t$: the interval between observations. 2. $\triangle Q$: the quantity of oxygen entering surface, i.e., the change in $\triangle Q_p$ values of Table 2. Unit: 10^3 c.c./m². 3. $\triangle Q/\triangle t$: the mean rate of exchange. Unit: 10^3 c.c./m²×months 4. $(P-p)_m$: the mean of values of oxygen pressure $P-p$ at beginning and end of interval. Unit: mb. 5. E: the exchange coefficient of oxygen. Unit: 10^3 c.c./m²×month×mb.

との両方が示してある。

此処で特に注意を要することは，(2) の場合には 1~2 月の場合をのぞき $P-p$ の値と dQ/dt の値はよく符号が一致しているが，(1) の場合には 4~5月，5~6 月，6~7 月の期間において符号が全く反対であるということである。又 (1) と (2) の E の値が割合よく一致しているのは，僅かに 1~2・2~3・3~4・9~10・10~11・11~12 月のほんの数例の場合においてのみである。しかも此の結果は飽和量の値として O_2' を用いたか，或いは C_0 を用いたかという僅かに 4 %以下の差異によつて惹起されたものであり，dQ/dt が $P-p$ に比例するという (4) 式の適用の誤りが指摘されねばならないだろう。

§3. Redffeld の誤謬

Dorsey によれば $d\tau$ 時間内に表面積Aの水面上に於ける気体の交換の場合は

$$dm/d\tau=(\alpha P-\beta C)\,A \qquad (5)$$

であらわされる。こゝに dm は $d\tau$ 時間内に A の表面積を通つて入りこむ気体の量，P は気体の分圧，C は水中の気体の濃度，又 α は Entrance，β は Exit coefficient とよばれる二つの係数である。こゝでもしも水の容積を V，溶解している気体の全量を m とするならば，

$C=m/V$，即ち (5) 式は

$$dm/d\tau=(\alpha P-\beta m/V)\,A \qquad (6)$$

或いは

$$dc/d\tau=(\alpha P-\beta C)\,(A/V) \qquad (6')$$

であらわされる

故に $\tau=o$ のときの濃度を C_o，$\tau=\infty$ のときの濃度即ち飽和量を C_∞ とすれば，

$$C-C_o=(C_\infty-C_o)\,(1-e^{-\beta A\tau/V}) \qquad (7)$$

となり，或いはさらに $C-C_o\equiv\triangle C$ とすれば

$$\triangle C/C_\infty=[(C_\infty-C_o)/C_\infty]\,(1-e^{-\beta A\tau/V}) \qquad (7')$$

となる

よつて水面における薄いフィルムによる酸素の吸収について調べるならば，今 $\tau=o$ のときの濃度 C_o を 0 とすると，C は時間 τ における濃度をあらわし C_∞ は $\tau=\infty$ の時の濃度即ち飽和量をあらわし，(7) 式は

$$C/C_\infty=1-e^{-\beta A\tau/V} \qquad (8)$$

となる

こゝで A は水面の表面積，V は水のフィルムの容積，又 β は水温を t とするとき

$$\beta=0.0096\ (t+36)\ \text{cm/min} \qquad (9)$$

であらわされる常数である

今 $V/A=0.05$cm即ちフィルムの厚さを0.05cmとすると，C/C_∞ と τ との間には Table 5 に示すような数値が得られる。即ち始めの酸素量を O とすると，次第に酸素が溶解して遂に 99 %の

Table 5. Absorption of oxygen by a thin film of pure water. Unit. τ=1 sec: C/C_∞=1 % temp.=t°C: V/A=0.05 cm.

t°C \ C/C_∞	10	20	30	40	50	60	70	80	99
0	1.0	2.1	3.2	4.5	6.0	8.0	10.5	14.0	39.6
10	0.8	1.6	2.3	3.6	4.6	6.4	8.2	11.0	31.2
20	0.7	1.3	1.8	2.9	3.9	5.0	6.7	9.0	26.0
30	0.5	1.2	1.6	2.4	3.3	4.3	5.8	7.7	21.6

Column. 1. C=concentration of oxygen at the time τ; C_∞=concentration at the time $\tau=\infty$; A=area of the water surface; V=volume of the film; β=0.0096 $(t+36)$ cm/min; $C/C_\infty=1-e^{-\beta A\tau/V}$.

飽和度に達するには水温が 30°C のときには 21.6 秒であり，10°C のときには 31.2 秒かゝり，水温の高い方が溶解速度はやゝ早いが，何れにしても飽和量に達するまでの時間は僅かである。又 V/A と τ との関係は，V/A が 0.05 cm の 2 倍即ち 0.1 cm になれば，τ は Table 5 に示された値の 2 倍となり，V/A が 0.05 cm の 10 倍即ち 0.5 cm になれば，τ は Table 5 に示された値の 10 倍即ち水温が 30°C で 99%に達するまでに 216 秒かゝるということになる。然も V/A が非常に大きい場合，即ち水面の内部においては，酸素の伝搬は拡散によるのであつて，最早上の関係では議論は進められない

さらに Dorsey によれば，$\tau=\infty$ のときの m の値を m_∞ とするならば，Entrance coefficient α は，$\alpha=\beta m_\infty/PV$ であらわされ，ヘンリーの法則から $p=Pm/m_\infty$ であるから $\beta m/V=\alpha\cdot p$, 即ち (6)式の $dm/d\tau=(\alpha P-\beta m/V)A$ に代入すれば，

$$dm/d\tau=\alpha\cdot(P-p)A \qquad (10)$$

となり，Redfield の (4) 式を同形の式が得られることになる。即ち (4) 式の Exchange coefficient E は Entrance coefficient α に等しいことがわかつた。よつてヘンリーの法則から導き出された (4)式は海面における酸素の溶解機構については適用出来るが，Redfield のように 200 m の深さにも及ぶ dQ の値を云々することは全くの誤謬であることが明言される。

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城ケ島における珪藻プランクトンの性状と海況の変動
(1952年3月～1953年5月)*

朝　岡　　治**

On the Variation of the Condition of Plankton Diatoms and the Sea at a Pier on Jogashima Island in the Period from March 1952 to May 1953

By
Osamu ASAOKA

Abstract: Planktological and oceanographical observations were made every third day at a pier on the east side of Jogashima Island from March 1952 to May 1953. Every time, sea water of two hundred cc was collected by Kitahara's water bottle, and in general all the numbers of diatom cells in the water were counted after condensation by centrifugal method. At the same time oceanogrophical elements were also observed.

(1) Generally speaking, the variation of the number of diatom cells shows a periodicity, namely the burst of plankton diatoms occurs three times in a year, in March and April, in June and in October, with reference to the former investigations at the same pier from June 1951 to March 1952.

And there can be be seen a close relation between the number of diatom cells and rain-fall.

(2) The "*Kyutio*" which means the flowing of an oceanic water mass into the coastal area, appeared several times in the observation period. In this paper some discussion is made about two cases of this phenomenon, the one in July 1952 and the other in January 1953, when the south or southwest gale blew hardly and the number of diatom cells decreased extremely.

§1. 観測場所及び方法

城ケ島は三浦半島の先端にあり，直接外洋に面した周囲約3.5kmの島である。北側は200mの水道をへだてて三崎町と相対しているが，附近には大きな河はなく，河水による陸水の影響は考えられない。観測は島の東側にある桟橋の先端の水深約4mの所で行つた。方法は少なくとも3日に一度ずつ北原式B号採水器を用いて，10時1回1mと3mの2層から海水300ccをとり，ただちにフオルマリンで固定した後その200ccをとつて12時間放置し沈澱させた。次に上澄をとり電動遠心分離器で5cc以下に濃縮し，その0.1cc中に含まれる細胞数をかぞえた。又同時に水温，塩素量，溶在酸素量，比重も測定し，1953年1月よりは珪酸塩の定量も行つた

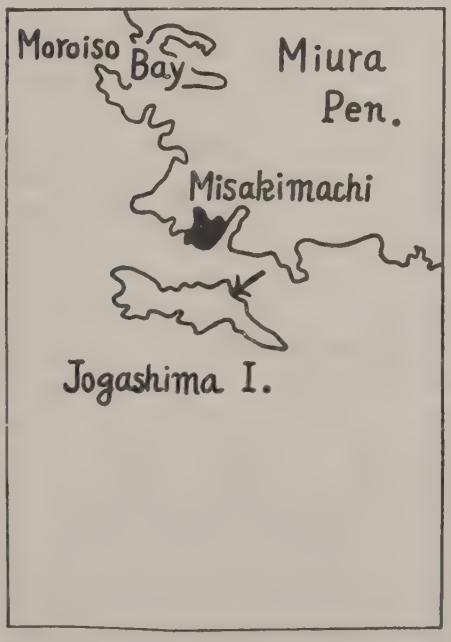

Fig. 1. A map of Jogashima Island and its vicinity. The location of this island is 35 08′ N, 139 37′ E, and the arrow denotes the station.

§2. 水理状態 (Fig. 2 a～d)

a) 水温　1m・3m両層とも最高は1952年8月30日の26.9°C，最低は1mでは1953年2月26日の11.1°C，3mでは同月28日の12.1°C

* 1955年7月14日受理

** 中央気象台, Central Meteorological Observatory, Tokyo.

である。又両層の最大較差は 1952 年8月4日の 2.9°C で、1m は 24.6°C. 3m は 21.7 Cである。

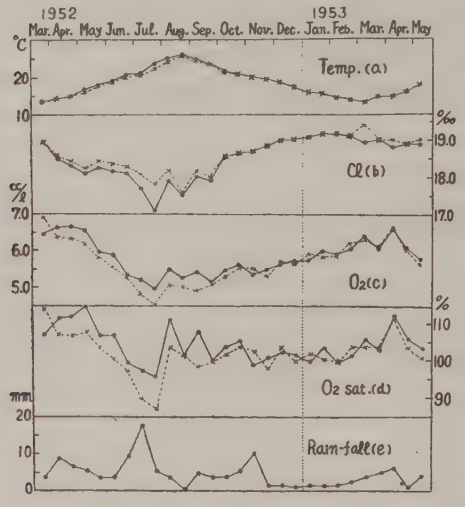

Fig. 2. (a–e) Seasonal variations of half-monthly mean values of water temperature (a), chlorinity (b), dissolved oxygen content (c), oxygen saturation percentage (d), rain-fall (e). Full line: for 1-m depth; broken line: for 3-m depth.

b) 塩素量 冬に高く夏に低い。最高は1953年1月13日の両層とも 19.26‰, 最低は 1952 年7月23日における 1m 層の 15.83‰ 3m の 17.33‰であり，両層の較差は 2.50‰で最大値となつている。このような成層状態は7月中旬の大量降雨と強力な日射に起因するのであろう。

c) 溶在酸素量及び飽和度 溶在酸素量 1m層の最大は 1952 年5月2日の 8.24 cc/*l*, 最小は同年7月 29 日の 4.19 cc/*l* である。又 3m の最大は 1952 年3月 21 日の 9.63 cc/*l*, 最小は同年6月 25 日の 3.93 cc/*l* で，両層の最大較差は 1952 年3月 21 日の 1.96 cc/*l* である。1952 年7月以外はほとんど過飽和になつており，1m 層最大は 1952 年5月2日の 143 %, 最小は同年 7 月 29 日の 81 % である。

§3. 珪藻プランクトンの性状

a) 細胞数 Fig. 3a には 1m·3m 層の各月15日ごとの全珪藻平均細胞数を、Table 1 には各月 15 日ごとの両層の平均細胞数を示した。以下細胞数はすべて 1*l* 中の値である。1m 層の最大は 1953 年4月3日の 400 万, 最小は 1952 年 5 月 22 日の 250 であり，3m の最大は 1952 年7月8日の 250 万, 最小は同年5月 18 日の 600 である。全細胞数についての両層の関係は複雑であるが，成層期には開きが大となり較差の最大は 1952年7月8日の 240 万である。細胞数 10 万以上の山は全期間中5回にわたつて出現している。

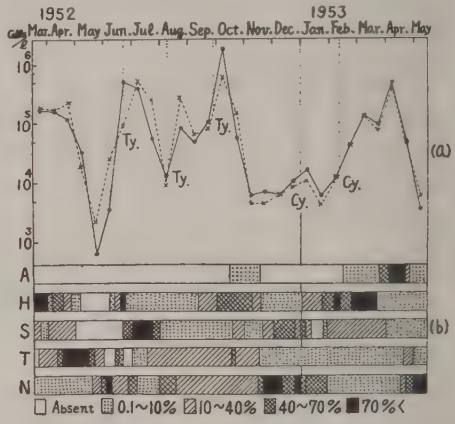

Fig. 3. (a, b) Seasonal variation of the number of diatom cells (a) and daily variation of the percentage compositions of several leading species (b). Full line: for 1-m depth; broken line: for 3-m depth; dotted line: the day when a typhoon (Ty) or a severe cyclone (Cy) passed. A: *Asterionella japonica*; H: *Hyalochaete* total; S: *Skeletonema costatum*; T: *Thalassionema nitzschioides*; N: Naviculoid Pennatae.

b) 組成 全期間を通じて 90 種の珪藻が出現する。Fig. 3b にはこの中の代表的な5種の全珪藻に対する百分率の日々変化を，Table 1 は各種珪藻の全珪藻に対する百分率の各月 15 日ごとの平均をとりその中の卓越する数種を示した。単調組成をなす場合も少なくなく，その種類は *Hyalochaete* 亜属数種, *Skeletonema costatum*, *Asterionella japonica* それに Naviculoid Pennatae がある。この Naviculoid Pennatae は特殊な1群なので後節において説明する。又 *Phaeoceros* 亜属及び *Rhizosolenia* 属はよく出現するわりに量

Table 1. The total number of diatom cells and percentages of several leading species to the total number of diatom cells. Both figures are expressed by the average of half-monthly mean values at the depth of 1 meter and 3 meters.

	Period		Cells/l	Leading species and the percentage
1952	Mar.	2nd	176,600	*Ch. compressus* (40), Nav. Penn. (37), *Skel. costatam* (8)
	Apr.	1st	167,000	*Ch. affinis* (28), *Thal. nitzschioides* (21), Nav. Penn. (11)
		2nd	181,100	*Thal. nitzschioides* (71), *Skel. costatum* (10), *Nit. seriata* (7)
	May	1st	26,200	*Thal. nitzschioides* (86), *Skel. costatum* (4), *Ch. affinis* (3)
		2nd	1,400	*Thal. nitzschioides* (34), Nav. Penn. (25), *Fragiralia* sp. (12)
	Jun.	1st	14,700	Nav. Penn. (61), *Ch. affinis* (8), *Thal. nitzschioides* (7)
		2nd	307,100	*Skel. costatum* (42), Nav. Penn. (20), *Ch. affinis* (19)
	Jul.	1st	471,900	*Skel. costatum* (67), Nav. Penn. (29),
		2nd	154,100	*Skel. costatum* (44), *Cerat. bergonii* (18), Nav. Penn. (17)
	Aug.	1st	11,000	Nav. Penn. (43), *Thal. nitzschioides* (22), *Skel. costatum* (2)
		2nd	187,000	*Thal. nitzschioides* (44), *Thal'sira subtilis* (22), Nav. Penn. (17)
	Sep.	1st	56,600	*Thal'sira subtilis* (22), Nav. Penn. (21), *Thal. nitzschioides* (17)
		2nd	94,200	Nav. Penn. (24), *Ch. lorenzianus* (21), *Bact.* sp. (20)
	Oct.	1st	1,276,500	Nav. Penn. (38), *Thal. nitzschioides* (16), *Ch. pseudocurvisetus* (14)
		2nd	104,200	*Ch. pseudocurvisetus* (37), Nav. Penn. (14), *Skel. costatum* (13)
	Nov.	1st	5,200	*Ch. pseudocurvisetus* (22), Nav. Penn. (20), *Skel. costatum* (15)
		2nd	5,800	Nav. Penn. (78), *Thal. nitzschioides* (4), *Skel. costatum* (4)
	Dec.	1st	6,300	Nav. Penn. (50), *Skel. costatum* (30), *Ch. lorenzianus* (3)
		2nd	9,400	Nav. Penn. (53), *Skel. costatum* (18), *Ch. lorenzianus* (5)
1953	Jan.	1st	14,000	Nav. Penn. (28), *Skel. costatum* (24), *Rh. stolterfothii* (6)
		2nd	5,200	Nav. Penn. (40), *Ch. socialis* (18), *Ch. pseudocurvsetus* (8)
	Feb.	1st	12,300	*Ch. socialis* (36), *Skel. costatum* (13), Nav. Penn. (12)
		2nd	44,100	*Ch. socialis* (34), *Ch. debilis* (24), *Skel. costatum* (13)
	Mar.	1st	159,400	*Ch. compressus* (27), *Ch. radicans* (26), Nav. Penn. (18)
		2nd	191,600	*Ch. socialis* (25), *Ast. japonica* (23), *Ch. holsaticus* (12)
	Apr.	1st	729,200	*Ast. japonica* (85), *Skel. costatum* (4), *Ch. debilis* (4)
		2nd	88,700	Nav. Penn. (23), *Thal. nitzschioides* (18), *Ast. japonica* (12)
	May	1st	6,000	Nav. Penn. (71), *Nit. closterium* (7), *Nit. fasciola* (6)

的にはわずかであること，1952年 6・7 月中には 17 種の珪藻があらたに出現した事等が目立つた

§4. 考　察

a) 気象現象とプランクトンの増殖　Fig. 3aに城ケ島附近に強い影響を与えた気象変動のあつた日を示してあるが，これらの日はそれぞれ細胞数の増加する初期に当つている．気象現象が直接植物プランクトンの増殖に関与するわけではないが，降雨による栄養塩の多い陸水の流入，海中に起るじよう乱，あるいは吹送流による水塊の交代等が増殖の契機を作り出すことは十分考えられる。さらにまた Fig. 2e の降水量と Fig. 3a の細胞数の変動を比較すると，雨の多い時期とプランクトンの多い時期とがよく一致している

b) 細胞数変動の週期性　さきに 1951 年 6 月より 1952 年 3 月にかけて当地で行われた川原田[1]の観測と連続して考えて見ると，今回は細胞数が一般に大きくかつ 1 月の山がより小さく出ている以外は 6 月，10月，3・4 月に細胞数の山が現われており，一見きわめて複雑な珪藻の量的変動も一定の週期性があることを示している

c) 卓越種と水温　1952年 7 月後半より 11 月

前半にかけては1種類が 70% 以上を示す場合がまつたくなく(Fig 3b), この時期の水温(Fig. 2a)はすべて 20°C 以上となつている。筆者はこのような現象の外洋における例として, 1953年1月～11月の金華山沖C線 (38 16′N, 142 00′E～38 16′N, 152 00′E) の本報告と同一採集法による表面珪藻資料についても, 8 月～10月の水温 20°C 以上の期間ではやはり著しい卓越種が無くなることを認めている

d) Naviculoid Pennatae の性状 Pennatae の中殻幅 5μ ぐらいのごく小型のものを総称して Naviculoid Pennatae とし百分率の変動を Fig. 3b に示した。その出現状態を見ると複雑でかつ存在しない時期がなく, Fig. 3a と比較すると細胞数の少ないときに高率を示す傾向がある。又この Naviculoid Pennatae は当地に近い諸磯湾における高橋[2]の報告中 *Navicula* sp. No.1 として小型底棲生物中常に高率を占めているものと同一種と考えられる。したがつて Naviculoid Pennatae の大部分は附着性のものであり, 補給源を海岸にもつこの一群は常時海岸附近に存在し, たまたま珪藻量の少ない外洋水のきたとき相対的に高率を示すのであろう。

e) 1953年 4・5 月における細胞数の激減 細胞数は4月3日の 400 万を最高にして 18 日には 200 万に下り, それから日を追つて減少し, 観測終了の5月 15 日には 2,000 となる。ここで減少を来したと考えられる2原因をあげて見ると, 第1は珪藻自体が死滅したことである。すなわち 4月3日の 400 万から4月 17 日の 37 万までの間は *Asterionella japonica* の単調組成であるが, 20日には6万に下り単調組成はくずれて全細胞数の½に相当する *Asterionella japonica* の内容物のない細胞が突然出現し, ついで *Thalassionema nitzschioides* は 22 日, *Guinardia flaccida* は 24 日, *Eucampia zoodiacus* は 26 日と約1週間の中に次々と内容物を失つた細胞が現われて死滅してゆく状態を示している。又 Table 2 の珪酸塩量は値が小さく個々の差もわづかであるが細胞数の最も少ない4月前半に最小となつているのが認められた つぎに第2の原因は動物プランクトンの増殖による捕食作用の増加である。さきに丸茂[3]は相模湾で5月に全プランクトンに対する動物種の百分率が最大となり, 中でも *Noctiluca scintillans* は全動物中 42% を占めていたことを報告している。筆者も4月後半の約10日間 *Noctiluca scintillans* の赤潮程度の増殖を認めており, これは前年5月も同様であつて動物プランクトンによる捕食作用が4月後半は特に大きかつたことが考えられる。さらに Table 2 の溶在酸素量及び飽和度は4月後半で特に減少しているが, これも動物プランクトンの呼吸による消費の増大と植物プランクトンによる酸素の生産の低下とが重複して現われたものと解することが出来よう

f) 急潮とプランクトン 本村[4]は沿岸の大急潮とは沖あいの暖水塊が多量に沿岸区域へ流れこみ, 沿岸広範囲にわたつて強流が生じ沿岸水温の急激に上昇する現象であると定義している。ここでは急潮の夏と冬の2例をとり上げてその第1条件である沖あい水の流入をプランクトン性状面から判定してみよう。Fig. 4a の 1952 年7月の例では前に述べた全細胞数が少なく Naviculoid Pennatae が高率を示す外洋水の特性に始まり,

Table 2. Half-monthly mean values of the total number of diatom cells, silicate, dissolved oxygen content and oxygen saturation percentage at the depth of 1 meter.

Period		Feb. 1953		Mar.		Apr.		May
Mean		1st	2nd	1st	2nd	1st	2nd	1st
Diatomeae	cells/l	11,800	44,600	177,000	290,300	867,200	128,500	6,000
SiO_2	mg/m³	290	288	280	295	218	299	351
O_2	cc/l	5.9	6.1	6.4	6.1	6.6	6.1	5.8
O_2 sat.	%	100	102	106	103	113	106	104

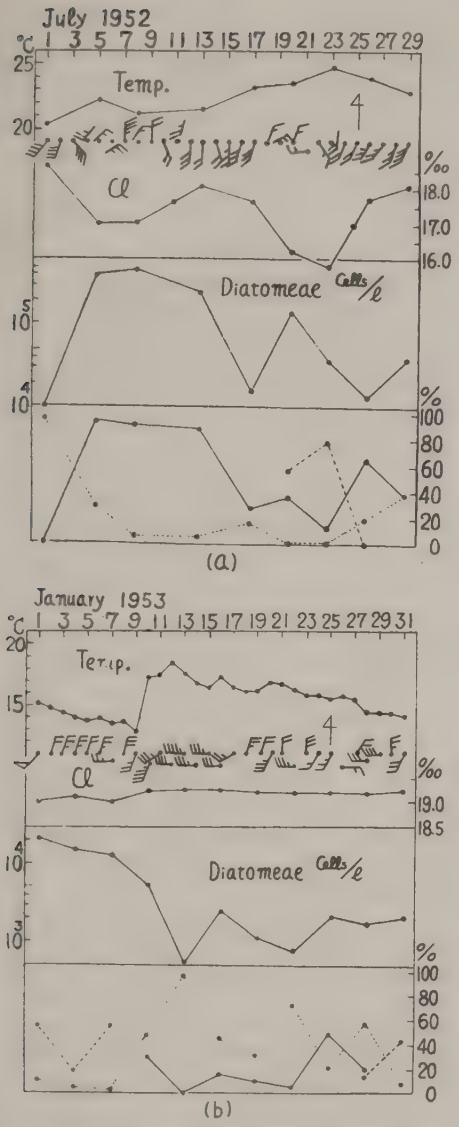

Fig. 4. (a, b) Daily variations of water temperature, chlorinity, maximum of the ten-minuts mean wind velocity within a day and its direction at the Tomisaki Weather Station, and the number of cells and the percentage compositions of the diatom in the period of "*Kyutio*". (a) Full line: Skeletonema costatum; broken line: *Cerataulina bergonii*; dotted line: Naviculoid Pennatae. (b) Full line: *Chaetoceros socialis*; broken line: *Skeletonema costatum*; dotted line: Naviculoid Pennatae.

5 日～13 日には一転して沿岸種の *Skeletonema costatum* が 90 %以上を占め細胞数は増加して沿岸性の強い水に変る。ついで 17日には *Skeletonema costatum* の百分率及び細胞数ともに減少し，Naviculoid Pennatae がわずかながら増加して外洋水の影響を示している。20・23 日は *Cerataulina bergonii* が突然多量に出現し，細胞数も増して沿岸水の傾向が強い。そして 29 日には 17 日以外はほとんど見られなかつた *Hyalochaete* 亜属を含み他の組成も 17 日と良く似た性質の外洋水となつている。次に Fig. 4 b の 1953年 1 月では1～7日は *Skeletonema costatum* を主体とし *Hyalochaete* 亜属の *Chaetoceros debilis, Ch. decipiens, Ch. didymus, Ch. lorenzianus, Ch. pseudocurvisetus* を含み細胞数の多い沿岸性の水である。ところが 10 日の水温急昇と同時に細胞数は減少し Naviculoid Pennatae の比率は増加して 7 月同様外洋水の到来を示している。それから 29 日までは 10 日以前とくらべて細胞数が少なく Naviculoid Pennatae が比較的高率を占め沿岸種の *Ch. socialis* が混つて外洋水と沿岸水の混合した状態を示す。しかし 31 日には 1～7 日にかけて出現した *Hyalochaete* 亜属 5 種を含み *Skeletonema costatum* の多い沿岸水となる。結局プランクトン性状より外洋水を判定する場合全細胞数の減少ということがもつとも良いめやすとなる　そこで細胞数の変動と水温・塩素量との関係を見ると，夏では塩素量に冬では水温にそれぞれ良い逆相関が認められる。特に 1952 年 7 月 29 日では外洋水が来たために水温がかえつて低下している場合も生じており，これは 7 月の気候が高温・多雨なので，海岸は沖あいに比して高温・低かんになつているためと考えられる。又逆に 1 月の場合は低温・寡雨であるので海岸は沖あいより低温となり塩素量の差は少なくなる。従つて急潮時には水温は著しく上昇するが塩素量の変化はわずかである。Fig. 4 a, b に示した風向及び風速は千葉県富崎測候所の 1 日最大風向及び風速（10分間平均値）であるが，夏・冬どちらの場合も南乃至南西の強風が吹いたとき急潮が起ることを示している

終りに当り観測に御協力下さつた久我雄四郎・

板倉博両技官並びに御指導戴いた丸茂隆三技官に深謝する。

§5. 要　約

1) 1952年3月から 1953 年5月にかけて城ケ島東岸で3日に一度ずつ観測を行い，珪藻プランクトンの性状及び海況諸要素の調査をした。

2) 珪藻細胞数の山は 3·4 月，6 月，10 月に起つており，さらに降水量との間に密接な関係が認められた。

3) 1953年 4・5 月の細胞数の減少について，珪藻プランクトンの死滅と動物プランクトンによる捕食作用の両面より考察した

4) 1952年7月と 1953 年1月における急潮では細胞数の減少と Naviculoid Pennatae の百分率の増加が見られ，水温・塩素量については7月では特に塩素量が1月では特に水温がそれぞれ急昇している。又何れの場合も南乃至南西の強風が吹いたとき起つている

文　献

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Notes on the Adult of *Cubiceps gracilis* from the Western Pacific*

By

Tokiharu ABE**

On December 25, 1954, the writer collected a large example of *Cubiceps gracilis* LOWE measuring 96 cm in total length at the Central Wholesale Market of Tokyo. It was taken by long line for swordfish off Hachijō Island. Several fish-dealers there told him that this species had appeared at the market very rarely and that they were in need of an authorized Japanese name for it. On checking the diaries written by the auther since April, 1947, when he began the daily visit to the market just mentioned, it has been found that on July 23, 1949, a medium-sized example of this species of *ca.* 40 cm total length was observed by the writer at the market. Mention was made of the pores of the skin and of the remarkably long pectoral fin. But at that time he was not specifically interested in gathering the specimens of this species. Recently, while working on Stromateoidei and Tetragonuroidei, he became much interested in the change of body form and the structure of the lateral pockets of the posterior part of the pharynx in these fishes, and on December 25, 1954, proposed to purchase all the examples of *Cubiceps gracilis* to be shipped to the market mentioned above. Fish-dealers recognize the fish easily by the resemblance with *Mupus japonicus* (DÖDERLEIN). Till April 7, 1955, additional four adult examples of *Cubiceps gracilis* were obtained and three or four badly-damaged examples were reported to have been shipped at the market. The latter examples were mostly not seen by the writer. He does not know the reason why so many adult examples were shipped to the market during some 100 days. According to the captain of the "No. 2 Kōryō-maru" who caught and shipped one of the adult example of *Cubiceps gracilis*, this fish is usually thrown away at fishing grounds because of its low price.† The flesh is white and oily as in *Ruvettus* or *Tetragonurus*, and only added to the flesh of sharks or other so-called rare fishes taken by long line for tunas in making fried fish-cakes.

So far as the writer is aware, adult examples of *Cubiceps gracilis* have not been recorded from Japanese waters. And if the small examples of *Mulichthys squamiceps* LLOYD (reported by OKADA & MATSUBARA, 1938, p. 159, and by KAMOHARA, 1938, p. 24; 1941, pp. 175, 176; 1952, p. 37), *Cubiceps squamiceps* (LLOYD) (reported by MATSUBARA, 1955, p. 579) and *Cubiceps natalensis* (GILCHRIST & VON BONDE) (reported by KAMOHARA, 1952, p. 35) represent distinct species from *gracilis*, the present paper is believed to be the first to record the occurrence of *gracilis* from Japanese waters.

Cubiceps gracilis LOWE

"Oki-medai" (new Japanese name††)

Seriola (*Cubiceps*) *gracilis* LOWE, 1843, Proc. Zool. Soc., pt. xi (1843), p. 82, Madeira.

* Contribution from the Tokai Regional Fisheries Research Laboratory, B—No. 217. Received July 16, 1955.

** Tokai Regional Fisheries Research Laboratory, and Zool. Inst., Fac. Sci., Tokyo Univ.

† In view of the fact that this species is taken commercially in Balayan Bay (Philippine Is.) (after HERRE & HERALD, 1951, p. 327) and that they collected 23 specimens, 75 to 138 mm in length, in the Lemery and Taal markets (Luzon) in April, 1948, it is not surprising that this species appears not infrequently in the western Pacific.

†† If *Mulichthys squamiceps* LLOYD recorded by OKADA and MATSUBARA (1938, p. 159) is identical with *Cubiceps gracilis*, the Japanese name, "Urokoibodai", proposed by them, may be used. Fourty-five days later, KAMOHARA proposed the name "Bōzu-konnyaku" for *squamiceps*.

(*continued on p. 62*)

Cubiceps gracilis GÜNTHER, 1860, Cat. Fish. Brit. Mus., ii, p. 389. —— REGAN, 1902, Ann. Mag. Nat. Hist. (7) x, p. 123. —— FOWLER, 1938, Acad. Nat. Sci. Philad. Monogr. 2, p. 196. —— LEGENDRE, 1940, C. R. Soc. Biogeograph. Paris, xvii, no. 146. Not seen in the original. —— SPARTÀ, 1946, Boll. Pesca Piscicolt. Idrobiol. Roma, xxii, pp. 17–21, pl. —— SMITH, 1949, Ann. Mag. Nat. His., ser. 12, vol. ii, pp. 849, 850. [Regards *capensis* (SMITH, 1849) to be identical with *gracilis*.] —— 1950 (1949), Sea Fish. Southern Africa, pp. 307, 308, fig. 856. —— HERRE & HERALD, 1951, Philip. Journ. Sci., lxxix, no. 3, pp. 324, 325, Luzon.

Atimostoma capense SMITH, 1845 (1849), Ill. Zool. S. Afr., pisc., pl. 24. Not seen in the original.

Cubiceps capensis GÜNTHER, 1860, Cat. Fish. Brit. Mus., ii, p. 389. —— REGAN, 1902, Ann. Mag. Nat. Hist. (7) x, p. 123. —— THOMPSON, 1916, Mar. Biol. Rep. iii, p. 105. Not seen in the original. —— GILCHRIST & VON BONDE, 1924, Fish. Mar. Biol. Surv. Rep. No. 3. Special Rep. No. IV, pp. 7, 8. —— BARNARD, 1927, Ann. S. Afr. Mus., xxi, pt. II, pp. 891, 892. FOWLER, 1938, Acad. Nat. Sci. Philad. Monogr. 2, p. 196. —— BARNARD, 1948, Ann. S. Afr. Mus., xxxvi, pp. 389–392, figs. 10–12.

Navarchus sulcatus FILIPPI & VERANI, 1860, Mem. Acc. Sci. Tor. (2) xviii, p. 7. Not seen in the original.

Trachelocirrus mediterraneus DOUMET, 1863, Rev. et Mag. Zool. 1863, pl. 15. Not seen in the original.

***Specimens studied*:**

Cat. No.	Locality	Date of catching	Total length (mm)	Fork length (mm)	Standard length* (mm)	Sex	Remarks
Abe 10155	33°30′ N 143°30′— 144°00′ E	December, 1954	*ca.* 960	*ca.* 900	*ca.* 825	♀	(Fig. 1). Surface temperature 19.6°C. Dermal pores photographed. (Fig. 4)
Abe 10169	Pacific Ocean	Early in January, 1955	1030	950	885		Lateral sacs of the posterior part of pharynx photographed. (Figs. 2 & 3)
Abe 10173	32°10′— 32°11′ N 140°10′— 140°50′ E	February 1, 1955	1050	950	890	♀	Surface temperature 19°C
Abe 10178	50 miles southeast of Torishima (north of Bonin Is.)	Middle of February, 1955	*ca.* 1020	*ca.* 940	*ca.* 860	♀	
Abe 10179			1140	1070	1000		
Not preserved	Between Hawaii and Midway, or 32°N; 172°W	December 21, 1954— January 16, 1955	1130				

If *Cubiceps natalensis* GILCHRIST and VON BONDE recorded by KAMOHARA (1952, p. 35) is identical with *gracilis* and if *squamiceps* is distinct from the latter, the name, "Chigo-medai", proposed by him for *natalensis* may be used for *gracilis*.

The name "Oki-medai" (meaning *Mupus japonicus* of the offing) has been used for convenience' sake by several fishermen for *gracilis*, and the writer proposes here to adopt this name as an authorized name (if *squamiceps* and *natalenses* are distinct from *gracilis*).

Proportional measurements. The following measurements are given in hundredths of the standard length**: Greatest depth of body 23.5 (26.0, 24.9, 26.6, 26.6), greatest breadth of body 15.2 (more than 13.0, 15.2,

* Measured to the hind end of the vertebral column. The end has been exposed by removing the skin and muscles.

** The order of the figures corresponds to the order of the five specimens listed above, which bear catalogue numbers.

16.9, x), least depth of caudal peduncle 7.9 (7.1, 7.5, 7.7, 7.0), length of head 27.2 (28.5, 27.0, x, 26.8), horizontal diameter of orbit 5.7 (left) & 5.8 (right) (6.8 & x, 5.7 & 5.7, x & x, 6.4 & x), length of snout 10.0 (left) & 9.1 (right) (8.7 & x, 8.9 & x, x & x, 8.8 & x), interorbital breadth (above centers of orbits) 9.4 (x, 9.6, x, 10.6), length of longest* dorsal spine 11.4 (11.1, 12.1, 13.7, 9.8), length of longest** dorsal fin-ray 9.4 (8.5, 7.0, 8.3, 8.5), length of longest† anal fin-ray 9.0 (8.3, 7.0, 9.5, 7.5), length of longest†† pectoral fin-ray 34.6 (left) & 34.6 (right) (32.2 & 33.1, 32.6 & 32.6, 32.3 & 33.1, 30.8 & 30.6 , length of longest§ ventral fin-ray 11.5 (left) & 11.6 (right) (x & x, 10.1 & 10.1, 11.0 & 10.5, 10.5 & 10.5).

Fin-formulae. D. XI. I 20 (all branched) [XI. I 20 (all branched), XI. I 20 (all branched), XI. I 20 (all branched), XI. I 20 (all branched)]. A. III 20 (all branched) [III 20 (all branched), III 20 (all branched), III 20 (all branched), III 20 (all branched)]. P. 22 (=ii+20) on both sides [21 (=ii+19) on both sides, 22 (=ii+20) (left) & 23 (=ii +20+i) (right), 22 (=ii+20) on both sides, 22 (=ii+19+i) & 21 (iii+18)]. V. I 5 (all branched) [I 5 (all branched), I 5 (all branched), I 5 (all branched), I 5 (all branched)].

Number of vertebrae. 31=12+19 in 1 specimen (Cat. No. ABE 10178).

Teeth and tongue. Teeth are present on jaws, vomer, palatines and tongue. The jaw teeth are rather short, arranged in a single row posteriorly and in two to several irregular rows anteriorly. The vomerine teeth are bristle-like, and arranged in a single row. The palatine teeth are bristle-like, arranged in a single row posteriorly and in two, or three, or several, rows anteriorly. The teeth of the tongue are arranged posteriorly in a single row along the middle line. They are bristle-like. In one specimen a similar tooth is present anteriorly in the middle line of the tongue. The tongue is broad, nearly rectangular (anterior margin being broadly rounded or rather forming a straight line), and the dorsal side is almost flat (slightly convex posteriorly).

Scales. The scales are cycloid, large and fairly deciduous. The number of scales along the lateral line is *ca.* 65 (left) & *ca.* 65 (right) (*ca.* 65 & *ca.* 67, *ca.* 67 & *ca.* 65, *ca.* 63 & *ca.* 69, *ca.* 65 & *ca.* 68). The number of scales above the lateral line and below the origin of the 1st dorsal fin 7 (left) and $6\frac{1}{2}$ (right) (6 & 6, $6\frac{1}{2}$ & $6\frac{1}{2}$, 7 & 6, 7 & 7). The number of scales above the lateral line and below the origin of the 2nd dorsal fin 7 (left) and $6\frac{1}{2}$ (right) (6 & 6, 7 & 6, 7 & $6\frac{1}{2}$, 7 & 6). The number of scales below the lateral line (above the anal origin) is *ca.* 22 (left) & *ca.* 21 (right) (*ca.* 20 & *ca.* 21, *ca.* 24 & *ca.* 22, *ca.* 20 & *ca.* 20, *ca.* 22 & *ca.* 22).

Branchiostegals, gills, pseudobranchiae, and gill-rakers. The left branchiostegal membrane anteriorly covers the right one in 3 out of 5 specimens. In 1 specimen they meet in mid-ventral line. In 1 specimen they are damaged. The number of branchiostegals is 6 (left) & 6 (right) (6 & 6, 6 & 6, 6 & 6, 6 & 6). Gills are 4 in number, and there is a large slit (having rakers along the margin) behind the 4th gill. Pseudobronchiae are well developed. There are no tubercles below them, but a few rakers are present near the upper-most gill-rakers of the 1st arch, which are marked with asterisks in the formulae. The number of gill-rakers on the 1st arch is 1*+11+1 +18 (left) and 1*+1*+1*+11+1+18 (right) (2*+10+1+18 & 1*+10+1+18, ?*+10+1+ 19 & 2*+10+1+18, ?*+11+1+19 & 2*+11 +1+19, 1*+11+1+19 & 3*+11+1+18).

General appearance, and color prior to preservation. The body is oblong-elongate, and not compressed. The eye is very large. The pectoral fin is remarkably long, much longer than head. The snout is rounded, and mostly naked, only the mid-dorsal part

* 4th (3rd, 3rd, 3rd, 3rd).

** 2nd (1st, 1st, 1st, 1st).

† 1st=2nd (1st, 1st=2nd, 1st, 1st).

†† 6th (left) & 6th (right) (6th & 6th, 7th & 6th, 6th=7th & 6th=7th, 6th & 6th).

§ 1st=2nd (left) & 1st=2nd (right) (× & ×, 1st=2nd=3rd & ×, 2nd & 1st=2nd, 1st=2nd & 1st=2nd).

being scaly. The anterior end of the base of the ventral fin is a very short distance in advance of the vertical through the postero-ventral end of the pectoral base. The ventral fins are received in a groove, which tapers posteriorly, and, passing the vent, reaches the anal origin. The innermost fin-ray of the ventral on each side is connected with the belly by a membrane. The first dorsal fin is received in a groove. The second dorsal, anal, pectoral and caudal fins are proximally covered by scales. The mouth is rather small; the posterior end of the upper jaw** is far in advance of the anterior margin of the orbit. The shape of the lower jaw is suggestive of *Tetragonurus*. The nostrils are paired on each side, and fairly close to the anterior end of the snout.

The color prior to preservation is uniformly brownish violet, only the pectoral fin being paler. The lining of the buccal cavity and the tongue are dark violet.

Lateral sacs of the posterior part of the pharynx (*figs. 2 & 3*). The posterior part of the pharynx is expanded laterally forming a pair of fairly hard sacs, each of which resembles a coiled abdomen of a boiled prawn. The internal dentigerous cavities of these sacs are continuous, but, externally, there is a dorsal bridge between the sac on either side. The long axis of the sac on each side is converging anteriorly and diverging posteriorly. The structure of the inside of the sac is complicated; there are five larger and six smaller muscular outgrowths stretching from the posterior wall of the sac. Each of these outgrowths resembles a cylinder or pillow or pier in shape, bears a large rectangular batch of teeth at its tip and a few (often paired) batches of teeth on its lateral sides. The inner surface of the outgrowth is naked. The concavities between these outgrowths and the anterior part of the sacs are beset with numerous horny dentigigerous outgrowths of varying shape and size which are supported by five to seven roots. These roots are often overlying on the roots of the neighboring outgrowths as in the dermal spines of *Diodon*. The teeth are all bristle-like and close-set. Differing from the figure and statement of *Cubiceps squamiceps* by MATSUBARA (1955), the teeth seem not to be articulated at the base, and the roots of the dentigerous outgrowths are slightly expanded distally in *gracilis* (differing also from *capensis* (after BARNARD, 1848, fig. 11b) in which the roots are attenuated). The bridges above and below between the two lateral sacs are internally naked and smooth.

Pores beneath the scales (*fig. 4*), *and dermal canals*. The presence of the pores on the surface of body is very remarkable. They are not visible if the scales are not removed, but as the latter are rather deciduous, observers may rarely overlook their presence. The pores are usually rounded and small. Their arrangement is not regular, but beneath each scale is a set of pores, some being larger and the others smaller. These pores lead to dermal canals which form a network over the muscles of the body. The central longitudinal canal begins from the upper angle of the gill-opening, runs straight slightly above the middle line of the flank anteriorly and along the middle line posteriorly, terminating just behind the posterior end of the vertebral column. Probably it is continuous with the central longitudinal canal of the other side of the body. Crossing the central longitudinal canal are some 27 vertical canals. They curve near their dorsal and ventral ends, and connected with one another by much narrower horizontal canals, or, rather by a network of smaller canals. An injection of "latex" solution shows that the canals are continuous almost all over the flank and that the pores of varying size are the outlets of the canals. It may be added here that the lateral line seems not to be in special relation with the canal system.

** In one specimen (Cat. No. ABE 10155), the length of the upper jaw is 6.7% of the standard length.

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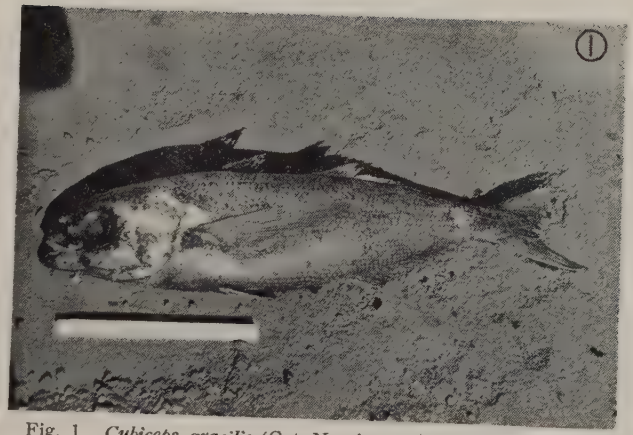


Fig. 1. *Cubiceps gracilis* (Cat. No. ABE, 10155). Total length 960 mm.

Fig. 2. *Cubiceps gracilis* (Cat. No. ABE, 10169). Dorsal view of the pair of the lateral sacs of the posterior part of the pharynx. Gills have been partly removed.

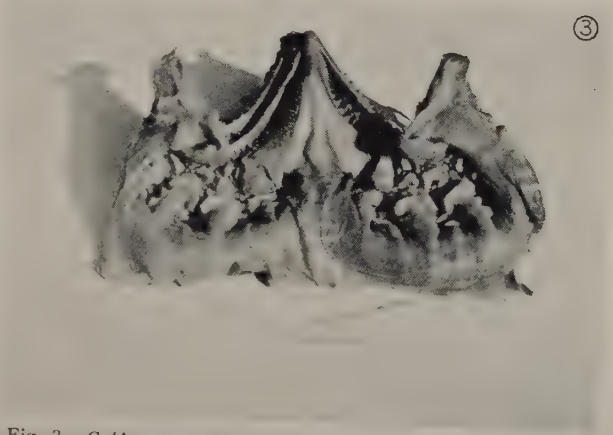


Fig. 3. *Cubiceps gracilis* (Cat. No. ABE, 10169). Dorsal view of the inside of the lateral sacs of the posterior part of the pharynx.

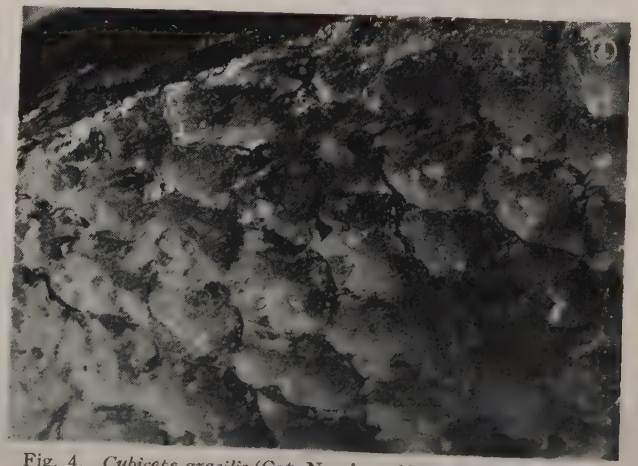


Fig. 4. *Cubiceps gracilis* (Cat. No. ABE, 10155). Dermal pores below the second dorsal fin.

錄　　事

日本の海洋研究とユネスコ

日　高　孝　次

第二次大戦の終了後全世界は改めて海洋資源の利用に注目をはらい始めた。文明国の海岸に沿つて多くの海洋研究所が設立された。米国ではスクリプス，ウッヅホール，ワシントン大学等既存の研究所は著しく拡張され，また大西洋岸，メキシコ湾岸，太平洋岸に合計5ヅ以上の研究所が新設された。カナダのブリティシュ，コロンビア大学には数年前に海洋学研究所が新設され，英国ではリバプール大学に海洋学部が追加され，ロンドンに近いウオルムリーには堂々たる国立海洋学研究所が最近活動を始めた。

また深海底を目標とする純学術的な海洋探検も盛に行なわれている。平和になつて間もなく 1947 年から8年に亘り Hans Pettersson 等は観測船‘Albatros’に依つて「スエーデン深海探検」を行ない，斬新な測器を用いて海洋底の起伏，沈殿物の層の厚さ，海底の年代，赤道水域に於ける海流等について多く興味ある結果を得た。1950年から 52 年にかけてデンマークの Anton F. Bruun は観測船‘Galathea’に依る「デンマーク深海探検」を指揮した。1951 年から2年にかけて英国の Thomas Gaskell は観測船‘Challenger’に依つて世界一周深海探検を行ない，太平洋の海底に於て幾多の興味ある新知識を得，1951年6月グヮム島とヤップ島との間に世界最深の海底（10863 米）を発見した。更に米国は 1950 年から 53 年に亘り数隻の船を太平洋に送り特に深海底の研究を目的として5回の探検を行なつている。

世界の人口は各々増加の一途をたどり，陸上資源，淡水等の鉱物資源は次第に不足を告げつつある。この問題に対する最良にして最も能率のよい解決は海洋を開発して海洋資源の増産をはかる事である。現在有力に最も陸上資源に富む国で海洋資源に頼る必要は殆どみとめられないにもかゝわらず，海洋の研究開発に特別な努力をはらいつつある。

天然資源に最も乏ぼしい民族は現在東南アジアに集中していて日本もその一つに属する。終戦以来数年，諸外国探検船が上記の如く太平洋に活躍し，その海洋学的研究を行ない幾多の重要な事実を発見しつゝあるにかゝわらず，海洋の研究に於ては如何なる国にもひけはとらないと信じている日本の海洋学者達がこの事態を見て切歯扼腕しているのは無理もない。

日本には海洋物理学（便宜上海洋の物理学，化学，地質学を総括する名称）の研究は気象台関係，水路部関係，水産研究所関係で各々業務の必要上行なわれているのみでこれを専門に研究する研究所が存在しない。この事は海洋物理学的な研究が極めて盛であり，またその方面の専門家の数の多い日本としては何としても遺憾な事であるが現在かかる研究所は全く一ケ所も存在していないのである。そもそも海洋なるものはその中で起る諸現象が自然科学のあらゆる分野に亘り，かつ相互に関連しているが故に海洋を能率よく研究するにはこれら自然科学のあらゆる分野，即ち物理学，化学，地質学，生物学，気象学等の研究部面を網羅する綜合研究所が必要であり，最近の各国で設立された研究所は何れもかかる綜合的な形態をとつている。

1951年から 52 年にかけて日本の海洋学者は一丸となつて海洋学の綜合研究所を新設すべく日本学術会議に建議したが日本学術会議は「時期尚早」との理由でこの建議を却下した。

当時東南アジアの諸国即ちヴェトナム，フイリピン，インドネシア，濠洲，タイ，ビルマ，インド，パキスタン，セイロン等の諸国は日本同様海洋資源の開発を意図してこの地域の何処かに国際海洋学研究所を設立し，主として基礎的な海洋研究を行ない資源の開発に資する計劃をもつていた。これらの諸国は「食糧農業機構（ＦＡＯ）」の下に「インド太平洋漁業会議（ＩＰＦＣ）」なるものが存在し，実際の水産漁業方面はすでに活動の域に入つていたので，この新らしい研究所の構想は基礎研究に限る事とし，資金を UNESCO に仰ぐ計劃ですでに1950年の UNESCO 総会に提出されていたのである。

1951年の秋日本学術会議に「海洋資源開発委員会」が設けられ，同時に「日本ユネスコ国内委員会」でも同様の委員会を作りUNESCO 関係の海洋学研究の火蓋を切つたが，1 年後共に廃止されて大した業績をあげるに至らなかつた。それ故その後日本ユネスコ国内委員会はこの問題をその最も重要な課題の一つに定め，幾多の困難を冒しつゝもこれと取組んで現在に至つている。

日本学術会議では当時ユネスコ委員会委員長であつた東大教授尾高朝雄が日本国内の海洋研究問題を国際問題

とし，インド太平洋地域の海洋研究所の計劃に日本も合流すべく計劃し，1952年 11 月にパリで開かれた第七回ユネスコ総会に日本側の動議として提出した。当時尾高教授はパリに出張し，私は米国テキサス州にいて同じくパリ出張を要請されたが連絡がわるくその運びに至らなかつたので，たまたま出席した湯川秀樹教授に依頼して海洋学関係の議題を担当して戴いた。

従来 UNESCO では未開発地域の資源開発問題を解決すべく努力しているが，その第一は「乾燥地帯の開発」である。日本には乾燥地帯が殆ど無いのでこの計劃に参加するわけには行かないが，併し資源に窮している事は同様であつたから 1952 年 11 月のパリに於けるユネスコ総会に於て「日本は乾燥地帯の代りに海洋の開発をしたいから UNESCO もこれを支持して欲しい」と申入れ幸にして UNESCO の賛同を得た。

依つて翌 1953 年春頃から日本ユネスコ国内委員会では事務局長鈴木九万の名に於て東南アジア・ユネスコ協力局々長 Dr. A. Wolsky との間に文書の交換が頻繁に行なわれ，「インド太平洋地域」の何処かに基礎的海洋学研究所を設立する必要性及びその可能性を論議し，また必要ならば如何なる形態が適当であるかを検討する国際会議を招集し，委員の半数は地元の海洋学者，あとの半数は欧米の一流海洋学者の参集をもとめてそれにＦＡＯ及びＦＯＡの関係者を交へ専門家会議を開く事が同意され，時恰も 1953 年 11 月 16 日マニラ郊外ケゾン市に於て「第八回太平洋学術会議」が二週間に亘つて開催されるのを機とし，同会議に先立ち 11 月 12, 13 両日に亘り UNESCO 及びＦＡＯ共同主催下にマニラ市のユネスコ国内委員会事務局に於て UNESCO 自然科学部長 Dr. Pierre Auger 司会の下に国際会議が開催された。日本からは尾高教授と日高孝次とが主席した。代表の顔触れは次の通りであつた。

Hans Pettersson（スウェーデン），Anton Bruun（デンマルク），A.C. Hardy（英），Th. Monod（仏），J. P. Tully（加），T. G. Thompson（米），D. V. Villadolid（比），Serene（ヴエトナム），Boon Mdrambarya（泰），J. D. F. Hardenberg（インドネシア），N.K. Panikkar（印），A. Tubb（香港），D. J. Rochford（濠），尾高，日高（日），Cecil Miles（FAO），Pierre Auger（UNESCO），A. Wolsky（UNESCO）他にオブザーバーとして E.H. Dahlgren（FOA，ジヤカルタ），M. J. Loboll（FOA，バンコック），L. G. Hadson（太平洋学術会議事務局長）が列席した。

かくて両日に亘る国際会議の結果かかる研究所が必要であり，日本を含むインド太平洋地域の何処かに海洋の物理学，化学，地質学，気象学及び生物学を対象とする海洋学研究所を一両年中に発足せしむる事とし，まず資料の蒐集や整理交換から始め経費 10 万弗を計上，関係国政府がこれを負担することとし，視察団が得られた暁には 25 万弗に増額する事を申し合せて解散した。当時インド「太平洋地域」とは南回帰線から北緯 35° に至り，西はアフリカ東岸から東経 160° に至る水域を考えたが，その後紅海もこの地域に編入された。以上の決議はその数日後に同地で開催された第 8 回太平洋学術会議でも重要決議として採用され支持されている。

しかるにこの会議に出席したカナダ代表の Tully は会議終了後泰国，香港，日本の海洋学を視察して帰国し 1954年に亘り「インド太平洋地域ではかかる基礎的の国際研究所は時期尚早でその必要を認めない」との報告書を提出し，また濠洲のユネスコ国内委員会でも同様の反論を出し，UNESCO の担当金の大部分を出している米国は予算を 3 万弗程度に削り，事業を主として人材の交換，専門家の養成に限るべきだと主張したのでこの計劃の実現性は極めて薄弱となつて来た。また翌 1954 年どこかで政府代表の会議を開く予定でもあつたのがこれも流れてしまつた。1954年 8 月濠洲のパース（Perth）で開かれた「第 2 回汎インド洋学術会議」の決議に依ればインド洋の各国はかかる研究所を必ずしも積極的に考えない方向に進んでいるようである。

以上の次第で UNESCO の国際海洋学研究所設立の問題は頗る覚束ない状態になつたが日本の海洋学者達はそれが UNESCO であろうが無かろうが国際的であろうが無かろうが兎に角海洋物理学（化学，地質学を含む）を主とし，これに海洋生物学を加えた所謂「綜合海洋学研究所」の必要を痛感している事に変りはない。必ずしも UNESCO に頼る必要はない。要するに海洋の研究を第一目標とする研究機関が建設さる可き事が焦眉の急である。未開発とされた太平洋は，終戦後スウェーデン，英国，デンマルク等の探検船が頻繁に来航してその神秘を曝き始め，次いで米国も 5 回に亘る探検を行つた。またハワイの水産研究所は赤道附近を極めて詳細に観測し，今まで謎とされていた赤道水域の海水流動を調査し終に「赤道潜流（Equatarial Undercurrent）」なる神秘的な海流を発見した。併もこれらの研究は目下更に続行中である。

かかる情勢下に於て日本が綜合海洋学研究所（物理学，化学，地質学，生物学，海上気象学等を網羅した形式の研究所を仮りにかく呼ぶ事にする）を一つも有たない事は極めて奇怪な事である。目下文部省に国立の海洋研究所の建設を要求する計画もある。

ユネスコの「自然科学部」では日本の立場をよく理解している。日本の海洋学の実力も知つている。インド太

平洋地域では海洋物理学に関する限り日本が独歩の地位を占めている事を考えれば 1953 年のマニラ会議に於ける日本の主張が決して無理でない事を良く知つている。その実力に於て敢て米国に劣る処なきに拘らず米国に十指とく存在する綜合海洋学研究所が日本に一つもない事はどう見ても不都合である。にも拘らず不幸にしてマニラ会議の決議を各国があまり賛成しない為日本が苦境に陥つている事を十分知つているのである。

たまたま昨 1954 年9月ローマで開催された国際測地学及地球物理学協会(ＩＵＧＧ) 第 10 回総会に際し「国際海洋学共同委員会(International Joint Commission on Oceanagraphy, JCO)」の会合があつた。この委員会は終戦後数年にして欧州で誕生し，海洋学の各分野の相互提携に依る海洋学の発展を図るものであつたが，1951年ブラッセルで開かれたＩＵＧＧ第９回総会の際に会合を開き財政上の理由から当分その機能を停止し，3年間様子を見る事に申し合せたものであつた。従つて1954年秋は丁度３年目になるわけでその何等かの形でこれを更生さすべきであり，その為には UNESCO に頼るべしとの意見が出た。また 1954 年 10 月4日～8 日ナポリで開かれたＪＣＳＵの事務局第７回会合及び第７回理事会 (The 7th meeting of the Bureau and 6th meeting of the Executive Board of ICSU) では Bruun (デンマルク), Sverdrup (ノルウェー), Deacon (英) 他生物学者及び地球物理学者各１名を委員としてＩＣＳＵを代表して UNESCO と交渉させる事とした。その頃 UNESCO の Dr. P. Auger から日本からもこれを提案すべしと要求して来たので事務局長鈴木九万の名に於てこれを提案し，国際海洋学諮問委員会の創設が世界の主な海洋国家から支持される事となつた。

本委員会の使命は世界の主な海洋学者を網羅する委員会を作り，これに依つて海洋学の国際協力を促進するにあつて，嘗ての JCO と略同一の内容を有つが UNESCO の支持があればその活動も期待される。1954 年 11 月モンテヴィデオで開かれた第８回ユネスコ総会の直前日本側は UNESCO に海洋学に関する国際的諮問委員会 International Advisory Committee of Marine Aciences) の設置を要求し，モンテヴィデオ総会に出席していた日本側代表，日本学術会議会長茅誠司が案を提出して賛同を得た。茅教授は年末帰朝して翌 1955 年 2 月 15 日，日本の海洋学者達と懇談会を開き会議の報告を行つたが，それに依れば UNESCO は海洋学の研究に対し努力を払い，まず 15 人位の委員からなる国際海洋学諮問委員会を設けることとし 1955 年 10 月東京に於て諮問委員会の設立準備委員会及び国際海洋学シンポジウムを開く予定である。処がその後 Dr.Auger は 10 月の設立準備委員会を半年程繰上げて５月 9,10 両日に亘つてローマに於て開催したい旨を突然通知して来たので日本からこれに対して代表を１名派遣する事となり日高孝次がそれに選ばれた。携行書類として 10 月のシンポジウムに関する議題と，それに招待したい各国の顔触れを準備していつたがローマについてユネスコ当局の意見を打診した処，この委員会はあまり大仕掛にスタートする事はしたくない。初めは地味に行く関係上，外部との関係に細心の注意を払い，ＦＡＯ関係との摩擦を極力避けるため水産関係，海洋生物学関係の議論をなるべく遠慮したい意向であつて，さし当り東京から提案したシンポジウムの議題の一つである「太平洋の生産力」はこれを撤回して，むしろ海洋物理学に重点をおく題目にかえて欲しいと云つた意向であつた。

会議は５月９日，10 時ローマの「ＦＡＯ本部」に於て開かれ Dr. Auger を議長として議事を進めた。出席者の顔触れは次の通りであつた。

Anton Bruun (デンマルク), A. A. Buzzati-Traverso(米), P. Groen(和), 日高(日), F. Koczy (スウェーデン), G. Laclavere (仏), H. Mosby (ノルウェー), D. J. Rochford(濠), R.B. Schaefer(米), H. U. Sverdrup(ノルウェー), A.V. Tåning (デンマルク), J. B. Tait(英), P. Tchernia(仏), これにオブザーバーとして S. R. Galler(米), J. Reymond(モナコ), G.Belloc(モナコ), ユネスコ事務局から P. Auger, 吉田正男, W. Moller, ＦＡＯから D. B. Finn (水産部長, G. L. Kesteven(生物水産課長) が出席した。

決議事項はいまだ抽象的の域を出ないが委員の数は 9 名で少くとも年１回は会議を招集する。初めから手を拡げない意味で地域分科会を正式に設ける事をしないが各地区のユネスコ協力局 (日本は東南アジア地区であるからジャカルタの協力局の管内である) の世話で本会議の直前に地域海洋学者の会合を開き，その決議を本会議に携行する事が出来る様に配慮する。そして委員の任命がきまれば今秋 10 月東京に於て「地域海洋学研究機関会議」,「海洋学シンポジウム」及び「海洋学諮問委員会」の 3 者を続けて開催する予定である。その時のシンポジウムの題目として次のものが考えられている。

Topics for Tokyo Symposium October 1955

Oceanic circulation which has bearing on the biological resources of the Pacific.

Discussion of relationships existing in the Pacific Ocean between such factors as ocean currents, upwellings, meteorological conditions

etc. and the distribution as well as movement of the living resources, in an endeavour to obtain an indication of the kinds of data on which emphasis should be laid in future surveys.

Oceanographic instrumentation pertaining to measurements in oceanic circulation.

Exchange of information concerning the latest developments in this field, as well as co-ordination in establishing efficient and reliable standard instruments and procedures in oceanographic measurements.

Exchange of Information concerning available and Needed Oceanographical Data.

Discussion on actual data and Practical plans for implementing the survey on data agreed to be of primary importance in the disscussions under item 1.

日本に於ける準備委員会 (Organizing Committee) は委員長日高孝次で，実行委員として宇田道隆 (主査)，須田皖次，三宅泰雄，新野弘，藤永元作，檜山義夫，日高孝次，他に UNESCO，文部省，日本学術会議，外務省の係者等関数名を推薦した。

以上の外 UNESCO は海洋学の国際人材養成及び交換の資金(フェローシップ)を本年度日本に2名分割当てているが我々は差当り海洋測器関係の少壮研究者を海外に送る意向を有つている。

附記：すでに決定した会議の日程と議題とは次の通りである。

a) 10月 17 日～18日

地域海洋学研究機関代表者会議

(Regional Meeting of Representative of Oceanographic Institutions)

b) 10月 19 日～22日

地域海洋物理学研究討論会議

(Regional Symposium on Physical Oceanography)

10月 17 日　情報の交換に関する部会

10月 20 日　海洋測器に関する部会

10月 21 日　海洋循環に関する部会

10月 22 日　補足的討論

(議題は別紙参照)

c) 10月 24 日～25日

海洋学中間諮問委員会

(Interim Advisory Committee on Marine Sciences)

なお，海洋循環に関する部会の座長は英国国立海洋学研究所長 G.E.R. Deacon 教授に決定した。

また，会場は国際文化会館の予定である。

海 洋 学 会　例　会

昭和 30 年5月 13 日 (中央気象台第2会議室)

最近の津浪について：三好　寿(東水大

昭和 30 年6月 14 日 (同会議室)

1. 選択的週期特性を持つ二重スローリーク附波浪計の理論：渡辺貫太郎(中央気象台)
2. 東北海区における観測鋼索の延ばし方について

秦　克己(函館海洋)(代読)

同 7 月 12 日 (水路部第一会議室)

1. 対流による大循環(その 1)　高野健三(東大理
2. 赤道附近の海流を推算する方法 (補遺)

七尾瑞樹(東大理)

寄　贈　交　換　図　書

(1955 年5月1日～7 月 31 日)

【国内の部】

○*List of Publications* (名古屋大学理学部出版部目録), **4**; ○*Memoirs of the Faculty of Engineering Nagoya Univercity*, **6**, 2; ○*Publications of the Astonomical Society of Japan*, **6**, 4, **7**, 1; ○*Report of Transportation Technical Research Institute*, **15**,(3冊); ○*The Journal of Earth Sciences, Nagoya Univertity*, **3**, 1; ○ *Ionospheric Data in Japan*, **7**, 3, 5, 6; ○運輸技術研究所報告, **5**, 4, **5**; ○水道協会雑誌, 247, 248, 294(2冊); ○雪氷, **16**, 5; ○地質学雑誌, **61**,715,716,717; ○地質調査所月報 **6**, 2, 3, 4; ○電波研究所季報, 2, 3; ○天文月報, **489**, 6, 8; ○東京工業試験所報告, **50**, 4; ○日本化学総覧, **29**, 5, 6, 7; ○日本航空学会誌, **3**, 16, 17; ○富士製鉄技報, **4**, 2; ○電波研究所総合目録; ○水産庁生産部漁船研究室研究報告, 第2号; ○淡水区水産研究所研究報告, **4**, 1; ○漁船研究技報, 6; ○小林理学研究所報告, **4**, 3-4.

【国外の部】

○*Allan Hancock Foundation Publications*, 15. ○*Pacific Science*, **9**,2; ○*Science*, **121**, 3143-3153; ○*Bull. Museum. Comparative Zoology* (Harvard College) **112**, 2; ○*Deutsche Hydrographische Zeitschrift*, **6**, 46; **7**, 3-4; ○ *Bulletin of Marine*

of Marine Science of the Gulf and Carilbean (University of Miami Marine Laboratory, Florida) **1–4,** (1–4); **5,** 1; ○*Anales de la Escuela Nacional de Ciencios Biologicas* **VIII,** 1–2; ○*Centro Talassografico Tirrenico Roma Courier,* 12; ○*Allan Hancock Pacific Expeditions,* 1; ○*Centro Talassografico Tirreno,* 14, 15; ○*Prace Geograficzne,* 1, 2, 3; ○*Przealad Geograficzny,* **XXVI,** 3; ○*Veroffentlichungen des Instituts für Mecresforschungin Bremerhaven,* **III,** 2; ○*Chesapeake Bay Institute, Collected Reprints,* **2**; ○*Chesapeake Bay Institute, Technical Report,* **IX**; ○*American Museum of Natu ral History Bulletin,* **103** 5, **104,** 4 (2 冊); ○*Novitates,* 1655, 1667, 1679, 1680.

学会誌投稿者へのお知らせ

投稿者各位の御協力により，順調に原稿が集まり，発刊も予定通り行える見通を得ました。印刷になる期間は，今号よりは，少しおそくなるかも知れませんので予め御承知下さい。尚編輯の能率化のため投稿規定をよく御参照下さい。

	締切	発刊
Vol. 11, No. 3	9月末	10月末
No. 4	11月末	12月末

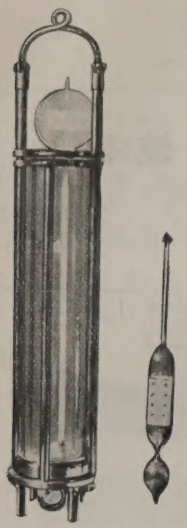
日本海洋学会誌編輯委員会

お知らせ

先頃発行しました"海洋観測指針"は好評を得ましたが，残部も殆んど無くなりました。現在増刷を考慮中ですが，御希望の向は中央気象台海洋課内福岡宛御申込下さい。

T.S.K. 鶴見精機

海洋調査観測用器機と航海計器



T. S トーメイ顚倒採水器
（寒暖計封入比重計付）

（捲上機）（測深儀）航海用及海洋調査用。
（手　動）250 M—550 M 三種アリ。
（携帯用）（河川、湖沼、石油井用）200 M。T.S.O.O 型½馬力
T.S-B.T 用電動捲上機
（電　動）T.SO 型　550 M　2 馬力
T.S I 型　1500 M　2 馬力
T.S II 型　3000 M　3 馬力
T.SIII 型　3000 M—5000 M　5 馬力及 10 馬力
T.S 海洋調査用ヘビータイプ電動捲上機（15 馬力・30 馬力）
（自記験潮器）（水位計）水圧式。フユース式。スチプンソン型。
（採水器）ナンゼン式。エクマン式。北原B号。ゴム二重筒表面採水器
T.S　トーメイ顚倒採水器（プラスチック製南日、岩宮式）
T.S　精密採水器（水平型）
（T.S 水深水温記録計）（T.S. バシサーモグラフ）70。150.300 M。
（顚倒寒暖計）防圧、被圧、検定付
（油井用連装採水器）（蔵田式噴井用点灯回転計）
（水色計）T.S 水色計（南日式）
（傾角度盤）深度更正表付
（採泥器）2 M 大型ピストンコーアサンプラー。ドレッヂ。
スナッパー式。岩宮式筒型。
（プランクトン採集器）表層。中層用。植物プランクトン用。
元田、井上式垂直各層別採集器
中井、岩宮式曳航採集器（濾水計、デプスレコーダー付）
中井式プランクトンネット用濾水計。
（深度計）岩宮式2号、6 号。
（流速計）エクマンメルツ式。プライス電音式。
T.S 自記流向流速計。港研数点流速記録計。
T.S 隔測流向流速記録計。
南日式 遠隔電接流速計。
（波高計）
（測程儀）特許 T.S 電気測程儀。舟尾測程儀。T.S サイドログ。
（旋回窓）
クリヤビユースクリーン）
○（其他の海洋調査観測機器）
○（T.S ステアリングスタンド。テレグラフ。其他の航海計器）

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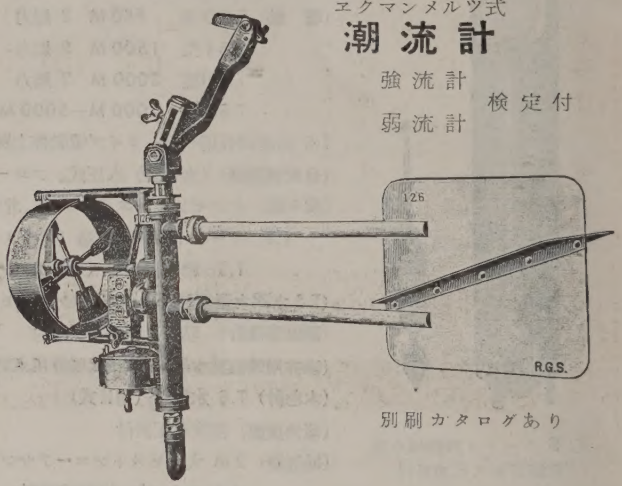
離合社の海洋観測器械

エクマンメルツ式
潮流計
強流計
弱流計
検定付



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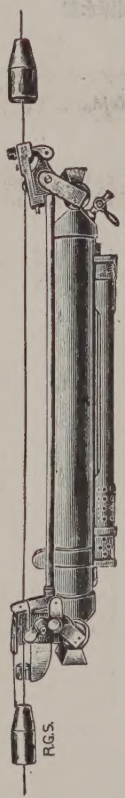

ナンゼン式連結転倒採水器

転倒寒暖計

營業品目

採水器	ナンゼン式（2種）エクマン式 特許北原式B号 特許KR式 特許神谷式航走用表面採水用
採泥器	新野式 丸川式 エクマンビルゲ湖沼用（3種） 田中式 新野式ドレツヂ（特許）
ブランクトンネット	北原式 丸川式 電気中層用 中井式
測深機及關係測器	手動式 ルーカス式 気象台式 湖沼用 深度計（メートルゲージ） 傾斜測定器（表付）
潮流計	エクマンメルツ式 強流弱流検定付 河川用プライス流速計

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電話 神田（25）0773・1513番
出張所 大阪市北区北同心町1丁目15番地

気象観測器械
海洋調査器械
顛倒温度計各種
（応需故障修理）
標準温度計各種
比重計各種

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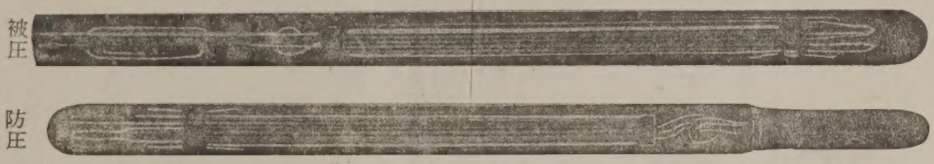

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August 1955

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